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Abstracts of Principal Articles

The British Timken New Building Project .....P. 4

At the Duston Works of British Timken, Ltd., a self-contained plant has been established for the automatic manufacture of tapered roller bearings, at output rates up to a maximum of 5 million per year. Cones and cups are produced on single and multi-spindle automatics. Swarf from these machines is fed along channels, below floor level, by air-operated rakes, and is delivered to a crushing plant, for disposal. Cones and cups are fed by conveyor to specially-developed equipment for marking, and chamfering where necessary. From this equipment, workpieces are delivered to storage hoppers, which feed two carburizing, hardening and tempering lines. One line, for cones and small cups, incorporates gas-carburizing equipment, and the work flows continuously through the various heating, quenching and cleaning stages. The other line is used solely for large cups which require press quenching, and parts are gas-carburized, quenched and cleaned in batches. They are then fed automatically to a flow-line installation consisting of a hardening furnace, two quenching presses, a tempering furnace and a shot-blasting plant. After heat-treatment, cups and cones are passed to hoppers which serve the grinding department. (MACHINERY, 92—3/1/58.)

Carbide Tools of Special Form for Interrupted Cutting .....P. 17

It was required to take interrupted boring cuts on a molybdenum steel forging with brazed-tip carbide tools. When tool forms with normal positive and negative rakes were employed, trouble was experienced, either due to chatter or chipping, regardless of the carbide grade, speed, and feed employed. The difficulty was overcome by modifying the tool form. A positive top rake was provided in conjunction with an edge chamfer, which gave an included cutting edge angle of 110 deg. With these tools, the work finish and accuracy were satisfactory, and important savings in time were obtained as compared with the alternative methods of turning with high speed steel or circular milling. (MACHINERY, 92—3/1/58.)

Turbine Blades Reclaimed by Electrolytic Grinding .....P. 31

In a considerable number of turbine blades, cracks were detected which had resulted from the grinding of the end surfaces of the roots. Removal of sufficient material to eliminate these cracks was frequently permissible, but attempts to reclaim the blades by grinding were not successful, because the depth of penetration was invariably increased regardless of the care that was taken. The problem was solved by removing metal by the electrolytic grinding process. For this purpose, a DoAll surface grinder with Anocut electronic control equipment was employed. The metal electrode wheel was impregnated with diamond particles, which control the gap between the conducting portion and the work, and facilitate stock removal. (MACHINERY, 92—3/1/58.)

Aircraft Manufacturing Practice—A Review of the British Industry.....P. 37

This article, based on the first part of a paper presented by Mr. L. G. Burnard, at the Production Engineers' conference on Problems of Aircraft Production, is concerned initially with various types of routing machines and their application for different purposes, including 3-dimensional contouring of integrally-stiffened forms. Wing skin milling is then considered, and reference is made to a tracer-controlled beam type machine, also a machine for producing large wing panels which obey the laws of straight line generation. Machining of high-tensile steels, and results obtained with Strasmann cutters are then discussed. Under the heading "programmed control of machine tools," the various available systems were mentioned, and a co-ordinate drilling machine designed and built by Vickers-Armstrongs (Aircraft), Ltd., was described. (MACHINERY, 92—3/1/58.)

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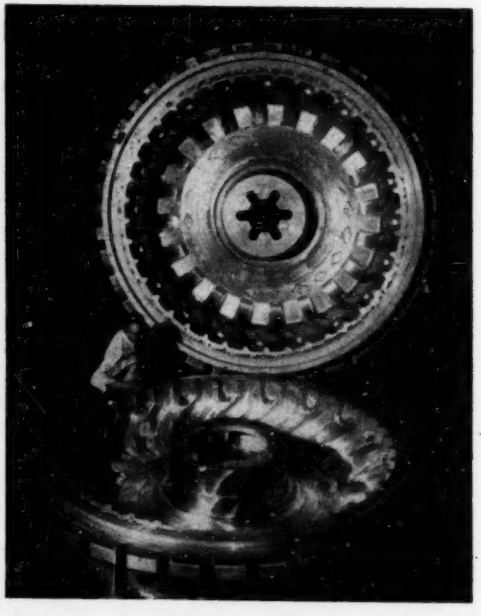
Claimed to be the largest light-metal castings ever made, these tyre mould halves were produced in one of the Alcoa foundries in Cleveland, U.S.A., for the Goodyear Tire & Rubber Co. The castings have an outside diameter of 8 ft. 10 in., and a combined weight of nearly 8 tons



Accuracy of Large Aircraft Parts

The modern trend towards integral construction of aircraft and missiles necessitates the production of various large and intricate parts, both for the main structural members and for reinforced skin panels. To facilitate the manufacture of certain of these components, and to reduce the quantity of material required, important advances have been made, for example, in the fields of heavy forging and extruding. As a result, it has been possible, in some instances, to provide much smaller machining allowances than were formerly required. Other parts are still machined from the solid with the result that a high proportion of the original material is reduced to scrap and heavy demands are made on available machine tools. Apart from the economies which integral construction may permit, as a result of the elimination of assembly operations, it is often possible to obtain a valuable saving in the weight of the finished structure without sacrifice of strength. During the course of The Lord Sempill Paper, which he presented at the Conference on Problems of Aircraft Production, organized by the Institution of Production Engineers, Mr. Boyd K. Bucey mentioned that weight might be reduced in this manner by as much as 25 per cent, and cited an example where the use of integrally-stiffened wing skin panels for a large jet bomber resulted in a saving of more than 900 lb.

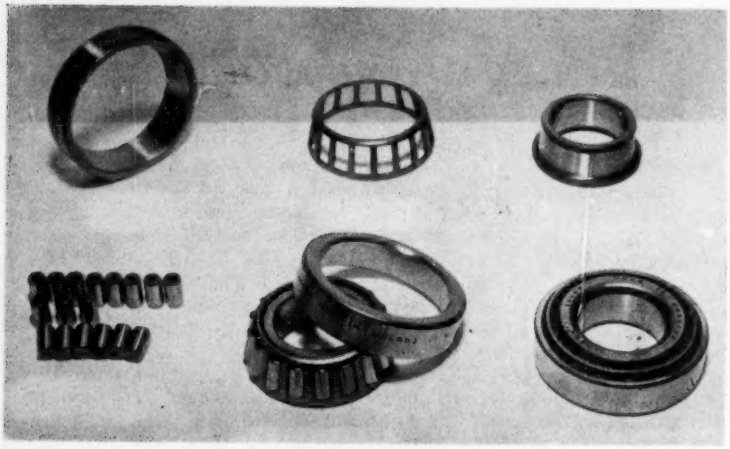
With the increasingly high performances demanded of aircraft, the problems of weight tend to become more critical, and it is necessary to reduce dimensional tolerances in order to ensure that while minimum thicknesses and sections are maintained to provide adequate strength, as little surplus material as possible remains. With the heavier metals the problem is, of course, accentuated, so that the production engineer is likely to be confronted with the necessity of holding still closer limits on materials which are more and more difficult to machine. In this connection Mr. Bucey pointed out that for aluminium alloy, 0·001 in. of thickness represented 0·014 lb. per sq. ft., whereas for steel the figure is 0·041 lb. It follows that for a large bomber, quite a modest increase in average wing skin thickness might result in a very substantial addition to the airframe weight, and a much greater addition to the all-up weight of the aircraft.

Despite future developments in "chipless" methods of forming metal, therefore, it is probable that it will be necessary to carry out extensive machining on materials of very high tensile strength, and to maintain tolerances which are very small in relation to the size of the components. To this end, further developments in machine and fixture design will be necessary in order to provide the requisite power and rigidity. With the object of achieving a better understanding between the user and the machine tool builder in the U.S.A., the Aircraft Industries Association set up an Equipment Committee to investigate requirements and ensure that they are satisfied. As an example of the work of this committee, Mr. Bucey stated that a new standardized design of knee type horizontal milling machine had been introduced which, as compared with that previously available, had four times the horse-power, was more rigid, and permitted more rapid loading. On this machine, be said, work was being completed in 2 hours which formerly occupied 16 hours.

Numerically-controlled machines will also facilitate the production of intricate parts of greater accuracy and uniformity, and should enable substantial economies to be achieved. The Equipment Committee has actively investigated the problems and advantages associated with the application of these machines, and evidence of the importance with which they are regarded is afforded by the fact that some 350 companies are engaged in development work on numerical control systems and data processing. It may be noted, moreover, that the U.S. Air Force has already placed contracts to the value of about 20 million dollars for the development and construction of numerically-controlled production machines and modifications of existing equipment.

Chemical milling is also likely to prove of great assistance in the attainment of higher standards of accuracy. Hitherto the process has been regarded as suitable mainly for operations on sheet materials, including shallow-sculpturing, tapering, and accurate thickness control. It is probable, however, that it will also enable components of other forms to be produced to closer limits than are possible with normal machining methods. A forging, for example, might be brought to approximately the required size by milling or other operations, and then reduced chemically to the finished

(*Continued on page* 55)



The British Timken New Building Project

Automatic Production Facilities for the Manufacture of Tapered Roller Bearings in Large Quantities

Some five years ago, British Timken, Ltd., Duston, Northants., began investigations in order to determine the most economical method for the manufacture of certain Timken tapered roller bearings which are required in large quantities. Since that time, various automatic lines for the manufacture of bearings have been designed, which have been the subject of continuous development, and these lines have varied in complexity, depending on the number of different sizes of components that each was required to handle. Clearly, the ideal and simplest production line would provide for the continuous manufacture of one size of bearing only, since, within certain limitations, the larger the output of a given type of product, the greater is the overall efficiency possible. In practice, no one size of Timken bearing was required in sufficient quantities to "saturate" a production line, and thus permit the most economical machine utilization. In consequence, a compromise solution to the production problems had to be found, whereby one production installation could be employed to manufacture a range of bearings, and this solution has become known as the New Building or N.B. Project.

At the outset, it was decided to house the automatic production facilities in a building separate from the main plant at Duston, and, initially, the building that was erected housed lines for making one cup and one cone. After some three years of development, during which period much valuable operating experience was gained, it was decided to increase the number of bearing sizes manufactured in this manner. The two original lines were dismantled, and the building was re-arranged to house two improved lines for the production of cups, and two for cones. These lines incorporated developments based on the experience of the previous three years, and it was considered that the installation would be justified by probable future standardization of bearing sizes. Both these lines are running at Duston at the present time, and form the subject of this article.

At present, the average output of the Timken N.B. Plant is about 3 million bearings per year. The outside diameters of these bearings range from 1½ to 3 in., and they are supplied principally to motor car manufacturers, both in this country and overseas. Three million per year is not the maximum output rate, however, and other sizes of bearings will be added to the range produced on the automatic lines, when demand reaches such levels that it is economical to install the necessary tooling, until the designed optimum output rate of 5 million bearings per year is achieved. The lines have been designed so that they have suffi-

cient flexibility to accommodate any bearing within the planned overall size range (1½ to 3 in. outside diameter).

NEED FOR MORE STANDARDIZATION

Economies resulting from automatic line production are readily apparent, and the cost of each bearing varies inversely with number of any one size that is made. As the size of the market for tapered roller bearings is only expanding slowly, the increase in demand for any one size, that is necessary to make automatic production worthwhile, can only be achieved by a greater degree of standardization than at present. It is considered by the company that there is still ample scope for standardization of tapered roller bearing sizes in this country, and it is hoped that, in the future, conditions will be achieved that will be comparable to those prevailing in the U.S.A. at the present time, where the same size of tapered roller bearing is used, for instance, in the front wheel assemblies of the majority of motor cars. In this connection it is thought that the establishment of the European Free Trade Area may result in an increase in the size of the potential market, which will enable the company to employ automatic line production techniques more extensively.

DEVELOPMENT PROBLEMS

In connection with the development of the automatic production lines, it has not only been necessary to design and build new machines and equipment, but also to acquire the necessary knowledge for their efficient operation and maintenance. A team of engineers and production staff has had to be established, and experience and skill in the solution of problems inherent in this method of manufacture have had to be gained. It may be of interest to note that many of the specialized techniques that have been developed have found wider application. For example, the methods developed for using carbide tools on both single and multi-spindle automatics have also been applied in the machine shop of the main factory. In this connection, it may be observed, the company acknowledges the co-operation of Tube Investments, Ltd., who are the makers of the hot-rolled tubes of special nickel alloy steel from which the major components for Timken bearings are made. It is considered that the high-quality rolling of Assel Mill tubing, and the careful metallurgical control exercised in the subsequent annealing operations, have contributed largely to the successfull application of carbide tooling to automatics.

THE NEW BUILDING

Known as the New Building, the shop that houses the automatic production lines is a completely self-contained unit, and its layout is shown diagrammatically in Fig. 1. It has a floor area of 33,000 sq. ft., and is divided into three main departments. These departments comprise an automatics shop for producing machined cup- and cone-blanks from tube (seen at the right in Fig. 1); a heat-treatment section (centre) for carburizing, hardening and tempering the blanks; and a grinding shop (left) for finishing the cups and cones, also the rollers. This latter department also houses the assembly, greasing, and packing sections. The

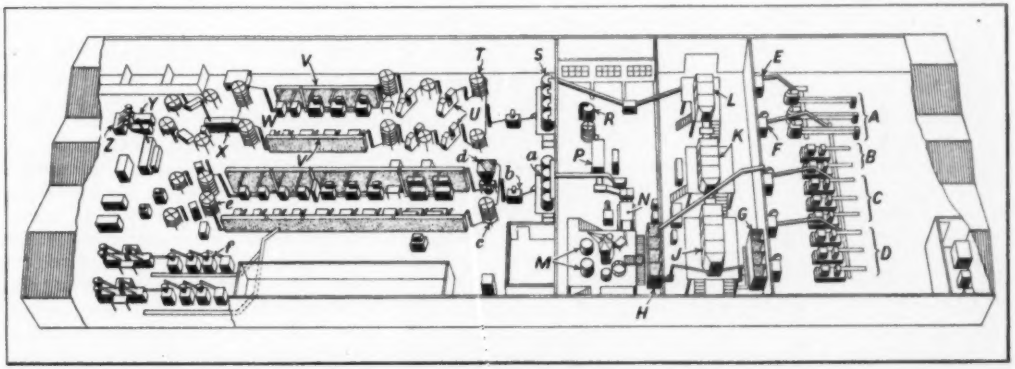


Fig. 1. Diagrammatic Layout of the N.B. Plant at the Duston Works of British Timken, Ltd., Showing the Disposition of the Various Departments. Work Flows from the Automatics Shop (Right) through the Heat-treatment Department (Centre) to the Grinding Shop (Left)

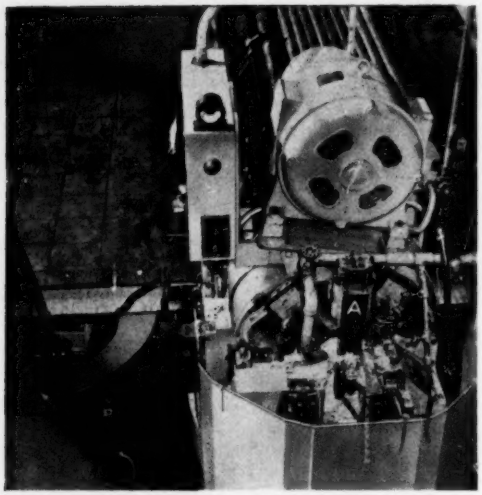


Fig. 2. One of the Specially-built Single-spindle Automatics for Machining Large Cups. Tungsten Carbide Tools are Employed, and Machined Cup Blanks are Delivered to a Band Conveyor at the Rear

New Building has its own boiler house, water storage, compressor house, and electrical substation, and it is air conditioned by means of six thermostatically-controlled Plenum batteries, which provide for extraction, filtration, and hot or cold recirculation.

The plant operates on a 5-day week, and, at present, the production workers number 120, of whom 20 are permanently employed on day shift, the remaining 100 being divided into three shifts. Of the total number mentioned, 10 are supervisors, 27 are inspectors, 34 are setters, and 49 are operators. There are 42 other workers, including 28 mechanical and electrical maintenance men (75 per cent of whom are fully skilled) and 14 shop cleaners, also a number of storekeepers. These numbers will gradually be reduced as additional automatic equipment is installed.

Tooling and "change parts" for the conversion of machines and equipment, enable the larger cup line to handle four different sizes of workpieces; the smaller cup line, five sizes; the larger cone line, three sizes; and the small cone line, four sizes. Components for two sizes of bearings are produced simultaneously on the four lines, and are brought together at the packing station to form complete bearing assemblies.

Throughout the plant, inspection is carried out on a statistical quality control system, and, at regular intervals, checks are made at each machine by patrol inspectors. Production operators are responsible for intermediate spot checks, and for taking the appropriate action, depending on the results of their own, and the patrol inspectors' findings. In addition, there is 100 per cent inspection at the end of the manufacturing sequence, to ensure that certain visual standards are maintained.

AUTOMATICS SHOP

The automatics shop is divided into four sections, referred to as lines. Line 1, indicated at *A* in Fig. 1, comprises three single-spindle automatics, equipped with tungsten-carbide tooling for the production of large cups (2¼ to 3 in. outside diameter); a separate machine for chamfering the tapered bore at the small end; and a Schmidt peripheral marking machine. The single-spindle automatics were built by the National Acme Co., U.S.A., to the specification of the Timken Roller Bearing Company of America. All three machines deliver workpieces into a bulk storage hopper, from which cups are mechanically sorted and delivered for chamfering and marking.

Line 2, indicated at *B* in Fig. 1, consists of two 5-spindle Wickman automatics of 2¼ in. capacity, equipped with tungsten carbide tooling for the production of small cups, with outside diameters ranging from 1½ to 2¼ in. The chamfer at the small end of the tapered bore of each cup is machined on the Wickman automatics, and workpieces are delivered directly to a single-deck spiral brush feeder, which supplies a separate Schmidt marking machine. The feeder is of a standardized design built by the company, to which reference will be made later.

Line 3, for the production of larger cones, was originally equipped with 2¼-in. capacity, 4-spindle Acme-Gridley automatics with high-speed steel tooling. At present, these machines are being replaced by 6-spindle Wickman automatics of similar capacity, which are fitted with tungsten carbide tools. These tools will provide for chamfering the bore, as for the smaller cups, and a 25-ton crank press is used for marking the cones on the broad end-face. This press is fitted with a fixture that was specially designed to prevent distortion of the rib (or flange) during the marking operation. Line 3 is seen at C in Fig. 1, and a single-deck brush feeder is installed to hold a buffer stock between the multi-spindle automatics and the marking press.

Line 4, for small cones, is indicated at *D*, and consists of three 1⅝-in. capacity, 4-spindle Acme-

Gridley automatics, a separate vertical chamfering machine, and marking arrangements similar to those of line 3. A small bulk storage hopper and sorting unit is provided to supply cones to the chamfering and marking equipment, and is similar to the unit in the section for large cups (line 1).

SINGLE-SPINDLE MACHINE FOR LARGE CUPS

One of the Timken-Acme Gridley single-spindle automatics for the production of large cups (line 1) is shown in Fig. 2. The machine is powered by a motor of 40 h.p., which drives the tubular spindle through multiple V-belts and gearing. Work material, in the form of tube, is advanced through the spindle from an automatic bar feed unit at the rear. This unit is equipped with an air-operated escapement mechanism, whereby one length of tube at a time is delivered to the feeding position, and there is a motor-driven pusher which exerts thrust on the end of the bar remote from the headstock of the machine. During each cycle of the machine, the work material is advanced until it contacts a roller stop on the vertical slide *A*, and it is then gripped by a mechanically-operated collet chuck in the spindle.

The slide *A* may also be seen in the close-up view of the tooling area of the machine in Fig. 3, and, in addition, there are front horizontal, front and rear angular, and longitudinal slides, all of which are cam operated. A tool on the front angular slide *B* rough forms a groove at the rear of the workpiece, to break down the material in readiness for parting off, and a form tool on the front horizontal slide *C* produces radii at the front and rear ends of the workpiece. Three tools are mounted on the longitudinal slide *D*, one of which provides for turning the outside diameter of the workpiece. The other two tools are carried on an auxiliary taper-turning slide, and machine the conical bore of the cup and produce a chamfer at the large end. For these operations, the work is run at a speed of about 500 ft. per min., and the tools are fed at a rate between 0·010 and 0·012 in. per rev. A copious flow of soluble oil coolant is maintained.

At the end of the sequence of cutting operations, just before the cup is cut off by a tool on the rear angular slide, a plunger with a taper lead is advanced into the bore of the workpiece. This plunger is an extension of the piston rod of the air cylinder *E*, which is angularly disposed below the longitudinal slide. After the cup has been parted off, it slides down the plunger and comes to rest in the chute *F*. The plunger is then automatically withdrawn, freeing the workpiece, which rolls down the chute towards the rear of the machine.

At the discharge end, the inclined chute delivers the workpiece to a band conveyor that connects all three single-spindle automatics with a vertical elevator. The band conveyor may be seen at the rear of the machine in Fig. 2, with the elevator at the extreme left. This elevator is of a standardized design that is used throughout the Timken plant, and will be described later. Cups are carried upwards and over a broad gangway at the front of the machines, to the bulk storage hopper *E*, Fig. 1, that serves the chamfering and marking units.

AUTOMATIC CHAMFERING MACHINE

From the bulk storage hopper, large cups are delivered, by way of a chute, to the chamfering machine, and the delivery arrangements are such that each workpiece is fed into the chute with the smaller end of its bore to the rear. The chamfering machine is located on the opposite

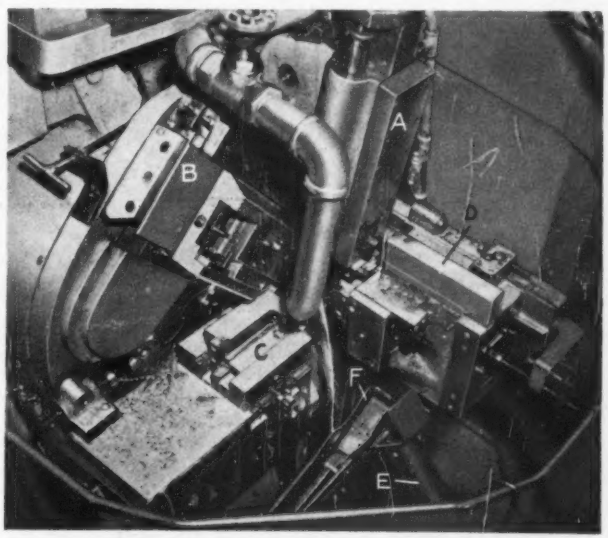


Fig. 3. Close-up View of the Tooling on a Single-spindle Automatic for Cups. The Tungsten Carbide Tools can be Pre-set in their Holders, to Facilitate Changeovers

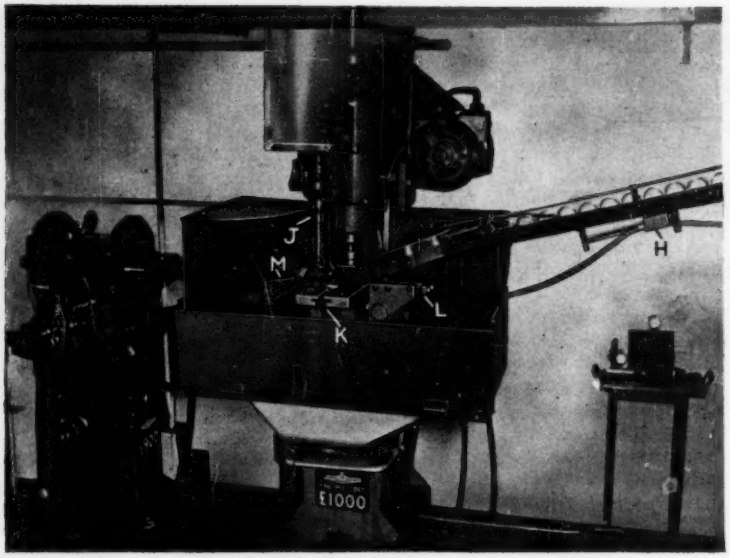


Fig. 4. Cups Roll Down a Gravity-feed Chute to the Cam-operated Feed Slide of the Chamfering Machine (Right). Chamfered Cups are Ejected into a Chute at the Rear, which Embodies a Turn-over Unit, and Leads to a Marking Machine

side of the gangway to the single-spindle automatics, and a view of this machine, and the associated Schmidt marking unit, is given in Fig. 4. As the cups are gravity-fed down the chute, seen at the right, they pass over two limit switches, one of which is indicated at *H*. When a sufficiently large stock of parts has built up in the chute, the upper switch (not shown) is held in the tripped setting, and the flow of cups from the bulk storage hopper is stopped. As the stock of cups in the chute is reduced, the lower switch *H* is released, and the flow of parts from the hopper is re-started. This arrangement ensures that there is always a large enough "head" of cups in the chute to feed the lowermost workpiece into the chamfering machine.

At the lower end of the chute, the cups are tilted through 90 deg., so that each is delivered to the feed slide of the chamfering machine with the small end of its conical bore uppermost. A motor, at one side of the head of the machine, drives the vertical cutter spindle through V-belts and gearing, and drive is also transmitted to a camshaft *J*. The cutter spindle, which is fed downwards by means of a bell cam on the shaft *J*, carries, at its lower end, a tool with a single high-speed steel bit, set at an angle of 45 deg. A cam on the lower end of the shaft *J* imparts motion to a feed slide that can move in the T-section guideways *K*. At one side of the guideways there is an air-operated clamping slide *L*, which is actuated by a bell crank coupled to an air cylinder below. This cylinder is connected to a valve that is operated by a cam on the shaft *J*. The arrangements are such that, at the start of an operation cycle, the feed slide is advanced to carry a workpiece into a position beneath the cutter spindle, and in line with the clamping slide *L*. This latter slide is then moved inwards, to secure the workpiece in position, and the cutter spindle is fed downwards. After the chamfer has been produced to the required size, as controlled by a stop, the cutter spindle is withdrawn, the clamping slide is retracted, and the feed slide is returned to its initial setting in readiness for the next cycle. When the next workpiece is advanced to the working position by the feed-slide, it ejects the chamfered cup into a chute at the rear of the machine.

The chute at the rear leads to the adjacent marking machine, and at its upper end there is a re-positioning unit *M*, of a standardized Timken design. This unit is of a cage-like construction, and consists of a series of small-diameter rods secured to end plates. Rectangular openings are pierced in the end plates, to permit the passage of the cups, and the complete assembly is twisted into a helical form, the long axis of the end plate at the entry end being horizontal and that of the plate at the exit end, vertical. Thus, as each cup passes through the unit it is tilted through 90 deg., so that it can roll down the chute to the marking machine with the small end of its conical bore towards the front.

CHAMFER CHECKING UNIT

From the Schmidt machine, the cups are delivered by chute to a vertical elevator, whereby they are transferred to an upper chute that leads

to bulk storage hoppers serving the heat-treatment department. In the outlet chute of the Schmidt machine there is a unit to check that the chamfer has been formed at the small end of the bore of each cup, and a close-up view of this unit is given in Fig. 5. Flat plates at either side of the unit are positioned so that the cup can just roll freely between them, and a "lead in" chamfer is machined on each plate to facilitate entry of the workpiece. A rectangular aperture is machined in the plate at the front of the chute (at the left in Fig. 5), and, through this aperture, can pass a swinging beam *N*, pivoted in a block attached to the plate. This beam is machined so that there is a projection at either end, and the projections extend into the gap between the plates. As a machined cup enters the unit, its periphery contacts the projection at the nearer end of the beam, and the form of the projection is such that the end of the beam is swung outwards, clear of the workpiece. The cup then rolls through the unit, and its periphery contacts the projection at the farther end of the beam, causing that end to swing outwards, so that the nearer end of the beam is moved inwards, and lies within the bore of the workpiece.

As the cup rolls forward, the trailing side of the bore surface contacts the nearer end of the beam, and tends to swing it outwards. If the bore has been correctly chamfered, this movement can be completed since the length of the beam is such that, as the farther end swings inwards, it just clears the face of the chamfer in the bore. The cup then rolls onwards, the trailing side of the bore surface contacting the farther end of the beam, and swinging it outwards as the cup passes out of the unit. Should the chamfer not have been machined, or should it be of inadequate depth, there is insufficient clearance for the farther end of the beam to swing inwards, and the workpiece is retained in the unit, between the ends of the beam.

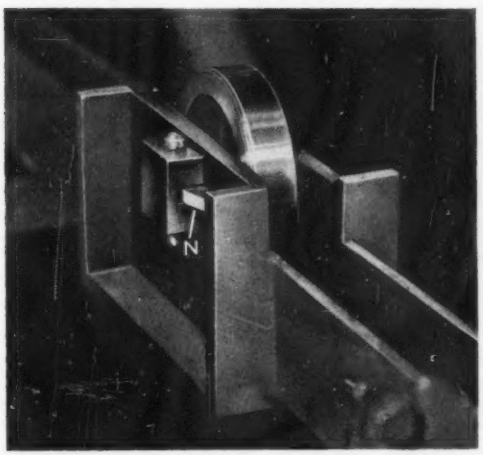


Fig. 5. A Feeler Unit is Incorporated in the Outlet Chute of the Marking Machine to Check that Each Cup has been Correctly Chamfered. Incorrect Cups are Retained in the Unit

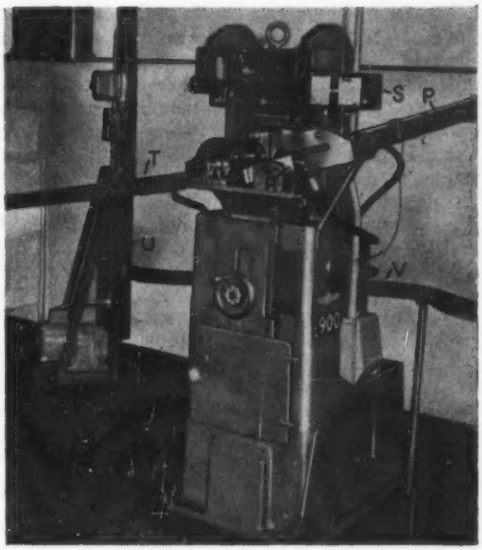


Fig. 6. One of the Schmidt Peripheral Marking Machines for Cups. These Machines are Fitted with Timken Equipment for Feeding One Cup at a Time to the Marking Position and Delivering it to a Gravity-feed Chute after Marking

As has already been indicated, the smaller cups are transferred from the Wickman multi-spindle automatics to a single-deck rotary brush feeder, by means of chutes and elevator units. From the feeder, the small cups are conveyed by chute to a Schmidt marking machine *F*, Fig. 1, which is also shown in Fig. 6. It has been equipped by British Timken, Ltd., and cups pass, one at a time, from the chute *P* to work-holders on an indexing drum. This drum is rotated intermittently in an anti-clockwise direction by a pawl and ratchet mechanism, operated by the hydraulic cylinder *R*. In the "12 o'clock" position, each cup is located beneath the marking slide S, which is advanced to the left. During this movement, replaceable punches, in a

holder secured to the lower part of the slide, impress the necessary identification letters and numbers on the periphery of the cup. At the next indexing movement of the drum, the marked cup is ejected into the chute *T*, and rolls downwards to the lower end of a vertical elevator, which delivers it to a chute leading to the storage hoppers in the heat-treatment department. The elevator is similar to the unit *U*, and this latter elevator serves for the transfer of large cups, as has already been outlined, and the chute from the Schmidt marking machine for these workpieces may be seen at *V*.

CHAMFERING AND MARKING CONES

Large cones are chamfered on the 6-spindle Wickman automatics, and only require marking on the broad end face before they are transferred to the bulk-storage hoppers in the heat-treatment department. Small cones, made on 4-spindle Acme-Gridley machines, however, must be chamfered and marked. On all the multi-spindle automatics, it may be noted, cups or cones fall into gravity-feed chutes after being parted off, and roll through small washing units as they pass to the belt conveyor at the rear of the machines.

The equipment for the chamfering and marking operations is shown in Fig. 7. From an intermediate storage hopper, cones are fed by way of the chute *W* to the chamfering machine at the right, which is fitted with Timken equipment, similar to that already described. The cones are delivered to a feed slide, and are ejected into a chute, at the rear, whereby they are transferred to the adjacent marking press. A holder is mounted on the lower end of the spindle of the chamfering machine, and carries a fly-cutter type tool for the chamfering operation. The cutter is fitted in an adjustable slide, that can be traversed in dovetail guideways on the holder, and can readily be set in order to maintain chamfer size, or to cater for different workpieces.

The marking press is a 25-ton Bliss machine, and has been specially equipped by the company. Chamfered cones are delivered, one at a time, to the work location in the lower member of a pillar die set, by the "head" of parts in the chute. The marking punches are fitted to the upper member of the die set. A horizontal air cylinder *X* is mounted at the front of the lower tool unit, and is coupled to a valve which is actuated by the cam *Y* on the press camshaft. As the ram of the press rises, after the marking operation, the valve is reset, the piston of the air cylinder is advanced, and the cone that has just been marked is thrust into an arcuate chute at the rear of the tools.

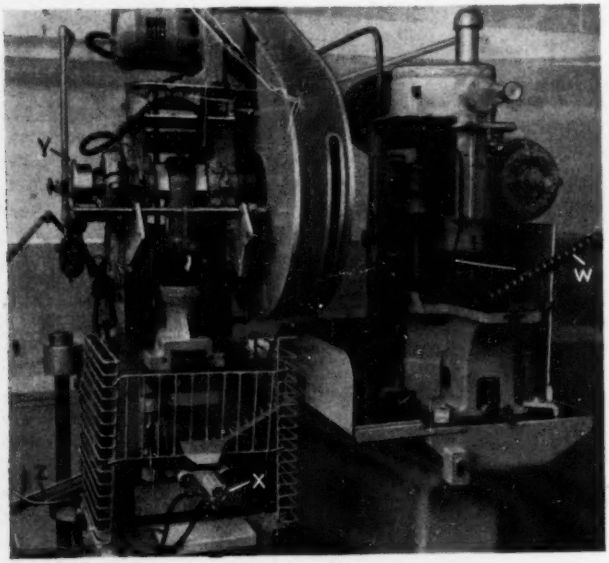


Fig. 7. Cones are Chamfered by Means of the Machine Seen at the Right, and are Marked on the Broad Face by Tools Fitted to the Specially-adapted Bliss 25-ton Press at the Left

Marked cones are pushed round the arcuate chute, as fresh workpieces are ejected, and are directed into the gravity-feed chute *Z*. This chute leads to a vertical elevator, and the cones pass upwards to a chute leading to the storage hoppers in the heat-treatment department.

The large bulk storage hoppers for the heat-treatment department are indicated at *G* and *H* in Fig. 1, and are of sufficient size to permit complete changes of tooling on the automatics without disrupting the production operations in the following departments. To reduce change-over time, and to eliminate adjustment of the tooling on the machines, the tools in each group, that are used for the different types and sizes of workpieces, are mounted in special holders and can be pre-set to gauges. Pre-set tools are carried in readiness for replacement or for changes of workpiece. Tool grinding and replacement, also the manufacture of certain tools, is undertaken in a separate enclosure, seen at the lower right in Fig. 1. Representative machining times are

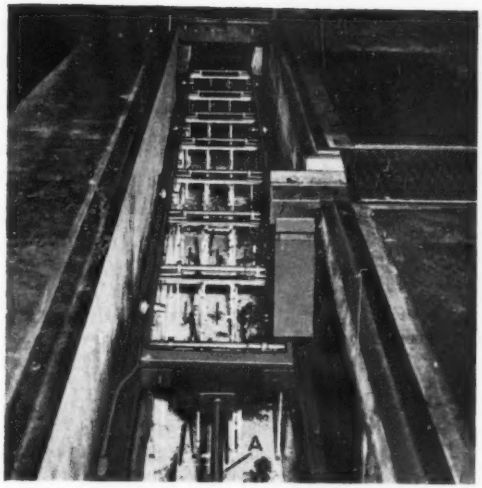


Fig. 8. One of the Swarf-disposal Channels in the Automatics Shop, Showing the Pneumatically-operated Rake Whereby Cuttings are Fed Towards the Separating Plant

32 sec. each for the small cones, and 42 sec. each for large cones.

SWARF HANDLING ARRANGEMENTS

Swarf produced on the multi-spindle automatics is ejected into ducts below floor level, and is moved along these ducts by pneumatically-operated forks. Swarf from the single-spindle automatics is carried along separate ducts by means of high-pressure jets of coolant. Both systems connect the automatics shops with the swarf house adjacent to the New Building, and the swarf is crushed and transferred to a container, to await collection and return to the steel works for re-melting.

In Fig. 8, one of the ducts serving the multi-spindle automatics is shown with the cover plates removed. The trolley carrying the forks travels on rails at either side of the duct, and is moved to and fro by means of a long air cylinder, the piston-rod of which is indicated at *A*. Eight fork members, pivoted on the trolley, hang downwards, and can swing upwards when the trolley moves in one direction only. Inclined pins, which project upwards from the bottom of the duct, retain the swarf when the trolley moves in that direction. During movement of the trolley in the opposite direction, the swarf is moved by the forks along the duct.

HEAT TREATMENT

Heat treatment of the cones and cups comprises carburizing for 7½ to 10 hours at 920 deg. C., to provide a case depth of 0·035 to 0·055 in., depending on the size and section of the workpieces; quenching in oil to refine the core; hardening by re-heating to 780 deg. C., and again quenching in oil; and tempering at 165 deg. C. for two hours, followed by air cooling.

Two entirely different installations are used for these operations, because certain of the larger cups are of a thin section and require controlled jig-quenching after hardening to prevent distortion, and to enable the minimum grinding allowance to be provided. Jig-quenching is not required for certain types of cups, however, neither is it necessary for any of the cones in the present range.

Machined and marked cones from the bulk storage hoppers *G*, Fig. 1, are directed by vibratory feeders to a belt conveyor, and thence to a gravity-feed chute leading to a vertical elevator. The belt conveyor may be seen in Fig. 9, with the chutes from the vibratory feeders at the left. Blades above the belt conveyor deflect the cones until they are aligned in a single row, before they are

Fig. 9. Close-up View of the Band Conveyor Whereby Cones are Delivered from Hoppers in the Heat-treatment Department to a Gravity-feed Chute Serving a Chain-type Elevator

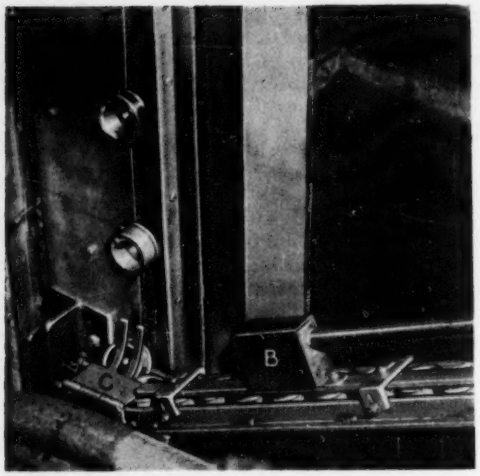


Fig. 10. One of the Switches for Controlling the Flow of Cones in the Gravity-feed Chute (Fig. 9), also the Loading Arrangements for the Elevator, are Seen in this Close-up View

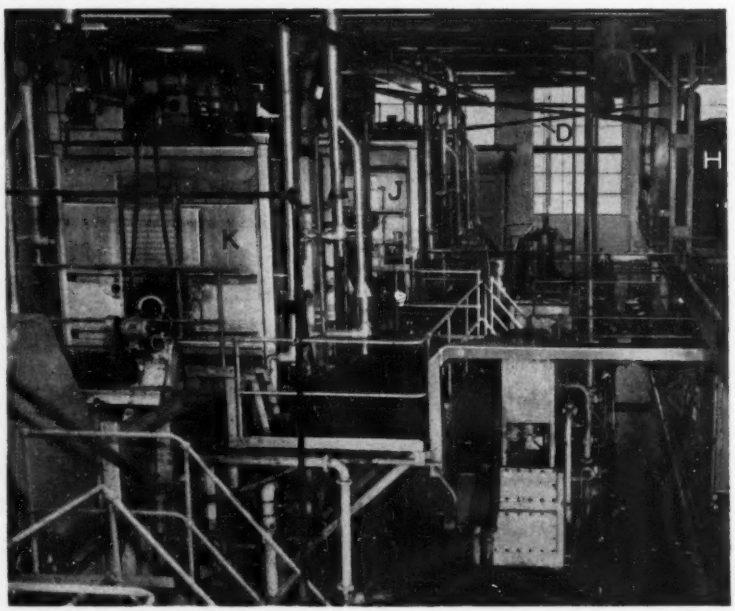
finally directed into the gravity-feed chute, seen in the background in Fig. 9.

STANDARDIZED ELEVATOR

A close-up view of the gravity-feed chute, and the elevator that it serves, is given in Fig. 10. As the cones approach the lower end of the chute, they pass under a series of limit switches which control the vibratory feeders and the belt conveyor. The upper switch (not shown in Fig. 10) is tripped as the stock of cones in the chute builds up, and feeding is stopped. When the stock of cones has been gradually reduced so that the upper-most cone passes clear of the lower-most switch *B*, feeding is resumed. The position of the switch *B* is such that there is always a sufficient number of cones above the lowermost workpiece to ensure that it is thrust into the pick-up position in front of the elevator.

This elevator is typical of many units installed in the N.B. plant. A column, constructed from steel sections, supports upper and lower chain sprockets. The lower sprocket is driven by an electric motor, through a reduction gearbox, and imparts motion to a loop of coarse-pitch roller chain. Evenly spaced along the chain are cranked pegs, which project outwards through a narrow gap between the side-members of the column and a central plate. The "rising" side of the chain loop is in line with the end of the gravity feed chute, and as each peg moves upwards it contacts the under-side of the lower-most cone in the chute. During continued movement upwards, the peg lifts the cup, which is thrust on to the peg by the action of a forked plate *C*, hinged above the chute, the peg passing between the forks. The cone is lifted clear of the chute, hanging from the peg, and is carried upwards and over the sprocket at the top of the

Fig. 11. A General View of the Heat-treatment Facilities for Cones and Small Cups. Parts are Delivered Automatically to the Gas Carburizing Furnace at the Rear, and are Transferred by Way of Quenching and Washing Units to the Hardening Furnace in the Foreground



elevator. Here, it is deflected off the peg, and into a gravity-feed chute, which, in this instance, leads to the carburizing furnace.

The carburizing furnace is indicated at *J* in Fig. 1, and may also be seen at the rear of the general view of the cone and small cup line, in Fig. 11. The bulk storage hoppers for cups are indicated at *H*, to correspond with Fig. 1. Cups that do not require to be jig-quenched are transferred from the hoppers *H* by vibratory feeders, an elevator, and a gravity-feed chute *D*, which connects with the chute from the elevator for cones. From the junction of these two chutes, a further gravity-feed chute leads down to the entry end of the carburizing furnace.

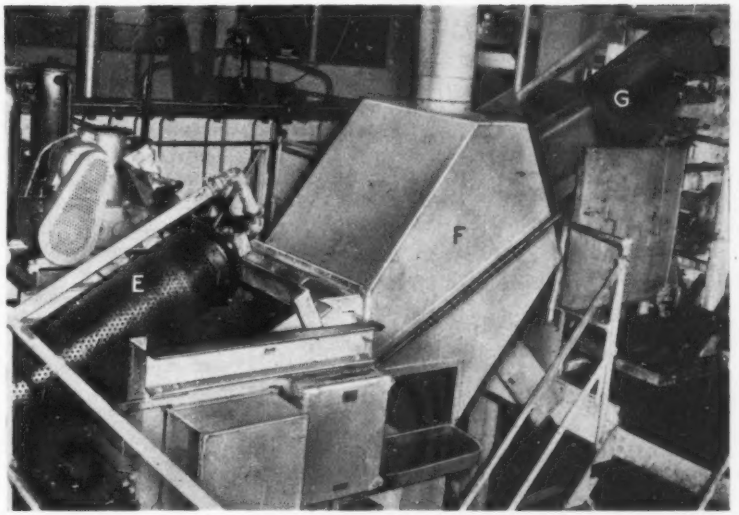


Fig. 12. Close-up View of a Rotating Spiral Feeder for Transferring Parts from the Quench Tank to a Washing Unit after Carburizing. A Second Feeder for the Delivery of Parts to the Hardening Furnace May be Seen in the Background

This furnace was supplied by British Furnaces, Ltd., to the company's specification. Town's gas is employed as the basis of the carburizing medium, and is treated in separate sulphur extraction and "RX" gas generating plants. Propane is finally added to the treated gas before it is delivered to the furnace, which is equipped with fully-automatic control, recording and safety arrangements. The latter provide for blowing out the carburizing gas mixture with a blast of compressed air, if the temperature falls below a certain value, since the mixture might then be dangerous.

Workpieces are fed into the furnace at a controlled rate, and are traversed through the unit by means of a rotating spiral feeder, made from nickel-chromium alloy. The spiral rotates first in one direction and then in the other, in order to provide an agitating action. Its motion is such that the charge is carried forwards for 50 sec., and then backwards for 45 sec., so that the workpieces are gradually fed towards the discharge end.

At the discharge end of the furnace, workpieces drop into an oil quench bath, from which they are removed by an inclined spiral feeder. This feeder may be seen at *E* in Fig. 12, and its lower end is located in the quench tank. Oil drains from the workpieces as they pass up the spiral, and falls through the perforations in the outer casing into a trough, whence it is returned to the quench tank. The spiral is driven by a motor at the rear, through a reduction gearbox, chain and sprockets. Workpieces are discharged from the upper end of the feeder into a washing unit *F*. Here, they are cleaned in a special paraffin-base solvent, and are then transferred, by a second inclined spiral feeder *G*, to the hardening furnace *K*, Fig. 1 and 11.

Workpieces are again traversed through the hardening furnace by means of a rotating spiral, and this stage occupies 2 hours. On leaving the furnace, the parts are quenched in oil, and then are fed into a washing unit before they are transferred to the tempering furnace *L*, Fig. 1. The washing and transfer arrangements are generally similar to those that have been described, and the hardening and tempering furnaces, which are gas fired, are equipped with automatic control and safety arrangements.

Every 30 min., one cup from the work passing through the carburizing, hardening and tempering section is broken and etched in nitric acid, so that the depth of case may be checked. This check is carried out by the operators in the section, and is supplemented by a laboratory check on one piece every two hours. Carbon content of the case is checked daily by the laboratory staff, to provide a warning of any faults.

HEAT TREATMENT OF LARGE CUPS

When cups that need to be jig quenched are being produced, they are delivered by vibratory feeders from the bulk-storage hoppers *H*, Fig. 1, to the second section of the heat-treatment department. A general view of this section is given in Fig. 13, where the hoppers are also indicated at *H*. The carburizing installation in the second section consists of two electrically-heated, pit-type furnaces, a quench bath with provisions for circulating oil at a rate of 2,400 gal. per min., and a circular trichlorethylene vapour degreasing unit. All this equipment is installed in a circle of 7 ft. radius, and a platform is provided to facilitate loading and transfer of the work.

The installation may be seen at the rear in Fig. 13, and the pit-type furnaces are indicated at *M* in this illustration, also in Fig. 1. Movement of the work between the various units is not automatic, but is carried out with the aid of an electric crane, which is mounted centrally on the platform so that its jib can be swung over all the units. From the hoppers *H*, cups are vibratory-fed into nickel-chrome alloy containers, each holding ½-ton. A roller conveyor is mounted in front of the hoppers to facilitate movement of the containers during the loading operations. At the mid-position along the conveyor there is a turntable, which connects with a short length of roller conveyor at 90 deg. to the main track, and the end of this short length lies beneath the path of the crane jib. Containers full of cups are arranged in stacks of three, and are then transferred, by means of the crane, to either of the two pit-type furnaces. These furnaces are fed with liquid, consisting of a mixture of alcohol and benzene, to provide the carburizing atmosphere.

At the end of the carburizing period, the stack of three containers is transferred by crane to the quench tank. From this tank, the containers are delivered to the degreasing unit *J*, Fig. 13. When the cups have been thoroughly cleaned, the contents of each container, in turn, are transferred to a hopper *K*, Fig. 13, at the side of the degreasing unit. Below the hopper there is a vibratory feed channel, which delivers cups to the upper end of a chute that leads to the infeed mechanism of the hardening furnace, indicated at *N* in Fig. 1 and 13.

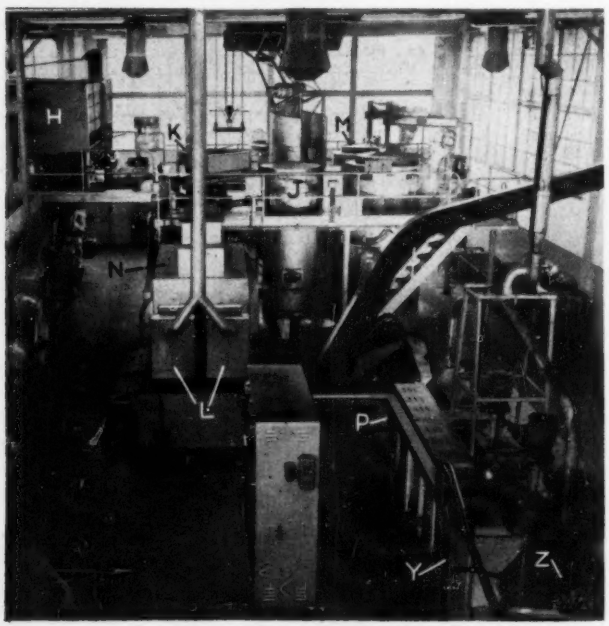


Fig. 13. The Heat-treatment Installation for Large Cups. Gas Carburizing is Carried Out with the Equipment in the Background, and Cups are Passed Through an Automatic Sorting Unit and a Distributor to the Hardening Furnace

For the quenching operation that follows hardening, the cups must be positioned with the large ends of their conical bores uppermost. If the positioning operation was carried out after the cups had left the furnace, they would lose an excessive amount of heat. It is therefore arranged that the cups enter the furnace guide channels with their large ends to the left (looking in the direction of travel), and are tilted through 90 deg. as they leave the furnace and enter the quenching presses.

A close-up view of the positioning arrangements for cups is given in Fig. 14. The chute from the hopper *K*, Fig. 13, is seen at *A*, and at one side there is a slide *B*. Cups are advanced, one at a time, to a position in line with this slide, which is fed forwards and withdrawn automatically by means of a crank and link mechanism, driven by an electric motor below the platform whereon the slide is mounted. To the end of the slide, adjacent to the chute *A*, is secured a bracket which carries a sensing probe. This probe can pass through an opening in the side of the chute, and is set at such a height

that it can enter the large end of the bore of a cup, but not the small end. If a cup is presented with its small end towards the probe, the latter is arrested, and when the slide is withdrawn, the cup is released and rolls down the chute *C*, and thence into the channel *D*. Should a cup be delivered to the sensing position with the large end of its bore towards the probe, however, the probe can advance into the bore, and through associated switchgear, a trap in the bottom of the chute is opened, and the cup falls into a lower chute, in line with the channel *D*. This chute incorporates a standard type of re-positioning cage *E*, and as the cup rolls through this unit it is turned through 180 deg., so that it enters the channel *D* with the large end of its bore on the far side (that is, on the same side as for the cups from the chute *C*).

Above the entry end of the channel *D*, there is a hinged wiper blade, which actuates the limit switch *F*. This switch is arranged to control the flow of cups to the sensing unit, and when the channel *D* is full of cups, the blade is held in the raised position, and delivery of cups ceases. The lower part of the channel *D* is aligned with a row of apertures in a distributor slide *G*. By means of an air cylinder *H* and associated valve gear, the slide *G* is reciprocated on round guideways above a series of vertical chutes that are located over the feed channels of the hardening furnace. There are eight chutes and channels, and cups are delivered to each of the apertures in the slide *G*, in turn, and are then transferred to the vertical chutes in rotation, and thence to two of the feed channels at a time. They are fed along the channels by pusher-bars, as indicated at J. The pusher-bars are advanced, and retracted, by links, oscillated by cams on a shaft below the bars, and the shaft is driven by a chain from an electric motor with an integral reduction gear box. The arrangement is such that when two of the pusher-bars are fully withdrawn, cups are fed into the associated feed channels, and when the pusher-bars are advanced, the cups that have just been loaded thrust the preceding cups along the channels, and the leading cups out of the furnace.

A furnace temperature of 780 deg. is maintained, and the time required for the passage of a pair of cups is 20 to 30 min., depending on the size. Movement is imparted to the cups in two channels simultaneously, and two cups at a time are ejected from the outlet end of the furnace, and pass down channels towards the two quenching presses *L*, Fig. 13. The channels are arranged in groups of four, each group serving one press, and the design is such that the cups are tilted slightly as they approach the ends of the channels

Fig. 14. Close-up View of the Sorting Unit for Cups which Ensures that the Large Ends of their Bores Face in One Direction. Below is the Automatic Distributor for the Hardening Furnace

nearest the presses. As they leave the channels, the cups fall on to sloping chutes, with the large ends of their bores uppermost, and slide down the chutes into the work locations of the presses.

Built by Geo. H. Whitehouse & Son, Ltd., to Timken designs, the quenching presses resemble those described in MACHINERY, 91/956—25/10/57. In this instance, however, they are entirely automatic in operation. Cups are held in the quenching jigs for 7 to 10 sec., depending on their size and section, and are ejected into an oil bath on the opposite side of the presses to the inlet chutes. Movement of cups through the furnace and quenching presses is automatically controlled, and as a pair of cups leave the presses, a signal is fed back to the pusher mechanism of the furnace, so that a fresh pair of cups is ejected, and two further cups are fed into the entry end. A time-delay is incorporated in the feed-back system, to ensure that the quenched cups have moved clear of the presses before two further cups are loaded. The control gear also synchronizes the movement of the air-operated distributor for loading the cups into the channels of the furnace.

Hinged flaps are provided in the outlet chutes leading from the quenching presses to the oil bath, and if, for any reason, a cup has not been

properly quenched in the jig, the flaps are held in the open position, and the cup falls through an aperture in the chute, into a reject bin below. Quenched cups pass over the closed flaps into the oil bath, from which they are removed by a scraper chain conveyor. This conveyor moves at a slow speed to ensure that the cups are adequately cooled, and the parts are carried upwards and delivered into a gravity chute that leads to the tempering furnace *P*, Fig. 1 and 13. The chute is in two sections, and the lower section is swung to and fro automatically, through a small angle, to distribute cups evenly on to the moving bed of the tempering furnace. This furnace is electrically heated, and the moving bed is driven by a steplessly-variable speed unit. Cups are discharged from the tempering furnace on to a vibratory feeder, whereby they are transferred to a sorting and turn-over unit, to ensure that they pass to the next stage in the operation sequence with the large ends of their bores facing in the same direction. They are then delivered by an elevator *Y*, Fig. 13, and a gravity-feed chute, to a spiral brush feeder, which may just be seen at *Z* in Fig. 13.

SPECIAL SHOT-BLAST UNIT

From the feeder, cups are delivered to a special shot-blasting machine, which has been designed and built by British Timken, Ltd. This machine is indicated at *R* in Fig. 1, and is also shown in Fig. 15, where the chute leading from the feeder is seen at *X*. The cylindrical body of the shot-blasting machine is rubber lined, and houses an impeller mounted on a vertical shaft. Drive to the shaft is taken from a motor which is carried on a bracket above the body, and shot delivered to the lower end of the impeller is slung outwards.

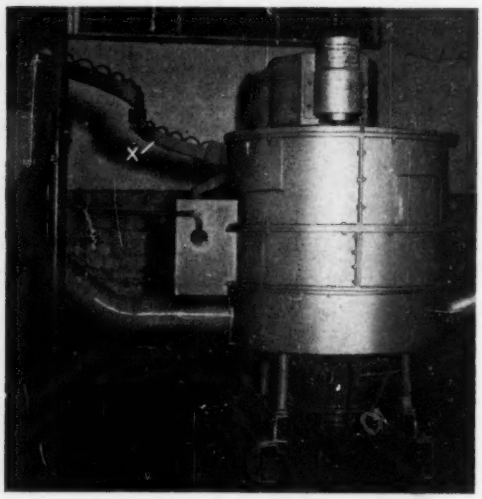


Fig. 15. This Automatic Shot-blasting Plant has been Developed by British Timken for Treating Large Cups. Similar Units are to be Installed for Cones and Smaller Cups

Cups are transferred from the delivery chute to a series of pegs, which project inwards from an annular member that surrounds the impeller and is rotated at a slow speed. As the cups are carried round, hanging from the pegs on the annular member, they are passed through the streams of shot from the impeller. The cups can move on the pegs due to the action of the shot, and are also passed over a number of rubber-covered members that project inwards from the casing, so that they are re-orientated in a random manner. These arrangements ensure that all parts of the cups are treated, either directly by shot from the impeller, or indirectly by shot which ricochets from the walls of the unit.

The shot-blast unit operates continuously, and cups are removed from the pegs automatically and pass down a chute that feeds a vertical elevator. This elevator serves an upper chute, whereby the cups are delivered to bulk storage hoppers in the grinding department. Shot is re-circulated, and is cleaned by compressed air in units mounted at either side of the machine. It is intended, eventually, to install three further machines of similar type for the treatment of the smaller cups and all cones. At present, the latter workpieces are shot-blast treated in the main works.

Oil for quenching is supplied to both heat-treatment sections from an adjacent service block, where there are two storage tanks, each of 5,000 gal. capacity, and multiple pumping sets. The oil is maintained at the correct temperature by means of two Heenan & Froude thermostatically-controlled coolers.

Grinding of cups and cones, also operations on rollers and final assembly, will be considered in a further article to be published shortly.

SILICONE RUBBER TAPES are now being made from "fusible" silicone rubber developed by the United Carbide Corporation, 30 East 42nd Street, New York 17, N.Y., U.S.A. These tapes are not sticky to the touch, but two tape-surfaces adhere when brought into contact, and light pressure is applied. One type of "fusible" silicone compound now available in limited quantities is an electrical insulator, whereas another compound which conducts electricity has been developed, and will soon be in production.

Carbide Tools of Special Form for Interrupted Cutting

By M. G. JENSEN *

By employing a tool of special form, the problem of applying carbide to an interrupted internal cutting operation was solved at the works of the Pratt & Whitney Co., Inc., West Hartford, Conn., U.S.A. The tool was developed for use on a Bullard 36-in. Cutmaster vertical boring mill. A molybdenum steel forging, seen in Fig. 1, has a Brinell hardness of 200 in soft condition, and is treated to a hardness of 371-400 Brinell, prior to finishing. Three intermittent cuts are required. One surface is an arc of 80 deg. on a 12½-in. diameter; another is an arc of 210 deg. on an 11-in. diameter; and the third is a groove root on an 11½-in. diameter.

It was decided to use butt-brazed tools to permit greater depth of carbide under the cutting edge, because of the high impact forces involved. The shanks, made from cold-rolled steel, were sandwich-brazed, and were milled to give a clearance angle of approximately 10 deg. Throughout the entire development, and subsequent production, not a single braze failure has occurred.

With conventional clearances of 5 to 7 deg., and rake angles from 10 deg. positive to 10 deg. negative, a variety of carbide grades was tried, at different feeds and speeds, but not one of these tools lasted through a cut without chipping or burning at the edge.

Development work up to this point, however, was not completely wasted. It was found that a negative rake of 5 to 10 deg. lessened the amount of chipping, but induced chatter because of insufficient rigidity. In addition, it was found that whereas a positive rake tended to stabilize the tool in the cut, and thus prevent chatter, chipping occurred almost immediately.

It was then decided to combine, in one tool, the advantages afforded by a positive rake and those afforded by a negative rake. First, a tool was ground with 5 deg. positive rake, 0·090-in. nose radius, and 15 deg. end cutting edge angle. Next, a 30-deg. negative rake chamfer, 0·030 in. wide, was ground on the side cutting edge, around the nose radius, and along the end cutting edge. Since the 30-deg. negative rake increased the included angle of the cutting edge, it was felt that the clearance angle could be increased to 10 deg., leaving a cutting edge with an included angle of 110 deg., as seen in Fig. 2.

This tool geometry proved successful from the start, since there was no chatter and no chipping at the cutting edge. A 0·050- to 0·075-in. deep cut was taken on the 11½-in. diameter, and at the ¾-in. shoulder it increased to ⅝ in. The cutting speed was 200 surface feet per min. and the feed 0·005 in. per rev. The chips were cherry-red, and showed about 50 per cent compression. Both tool and workpiece remained exceptionally cool, although the cutting edge was red when it left the workpiece. No welding of metal to the tool occurred.

Next, this geometry was applied to a ¾-in. wide grooving tool, with a 0·090-in. radius at each corner. The chamfer on the end of the tool was

Fig. 1. The Work is Here Seen in the Fixture on the Vertical Boring Mill After the Rough Intermittent Cuts have been Completed

* Pratt & Whitney Co., U.S.A.

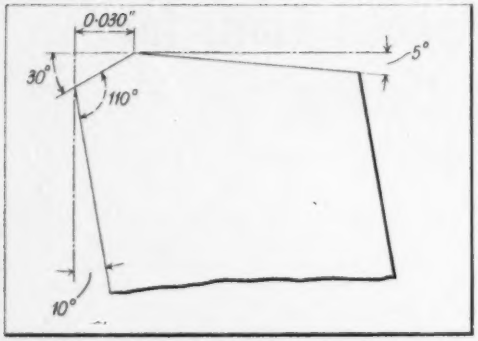


Fig. 2. The Width of Chamfer, here 0·030 in., is Twice to Three Times the Feed Rate, and Approximately One-third of the Distance that the Chip Rubs on the Tool Face

reduced to 20 deg. but was maintained at 30 deg. on the radii, to withstand the impact on entering the cut. Metal removal amounted to 0·050 in. at each side, and 0·050 to 0·075 in. at the bottom of the groove. The cutting speed was 190 ft. per min., and the feed 0·004 in. per rev.

Surface finish, between 20 and 30 micro-inches in any direction, was very satisfactory, and a tolerance of 0·010 in. could be held without difficulty. Cutting time was reduced from 49 min., when high-speed steel tools were used, to 8 min. with carbide, and tool life was at least trebled.

An attempt was then made to use carbide tools for the interrupted cuts with the forging in the dead-soft state (Brinell 200). Conventional tool geometry resulted in the same difficulties, which were, however, overcome with the adoption of the 30-deg. negative-rake chamfer. In one roughing cut, a ⅝-in. depth of material was removed from the 11-in. diameter surface, at a speed of 200 ft. per min., and a feed of 0·015 in. per rev. The groove was plunge cut at 225 ft. per min., and a feed of 0·008 in. per rev. For the 12½-in. diameter cut, the speed and feed were the same. Next, a boring tool was applied at 225 ft. per min., and a feed of 0·020 in. per rev. A tool lasted for more than 10 workpieces, and then only light grinding was necessary.

Originally, the operation was performed by circular milling, and removal of the necessary 21 lb. of metal required 85 min. At present, turning is completed in 24 min. In addition, the number of times that the work is handled has been reduced from six to two.

The same tool geometry has been applied to jig-boring operations. In one instance, an arc of 270 deg. was bored to 4-in. diameter from an initial 3-in. diameter. The material was a mild steel forging. This tool performed well, with good life, at a speed of 300 ft. per min., a feed of 0·006 in. per rev., and a 0·1-in. deep cut. A boring bar deflection of about 0·005 in. was caused by the 30-deg. chamfer angle, but the effects were easily corrected by a clean-up cut at the same setting. Even with intentional stalling of the machine while cutting was in progress, the carbide did not chip. Because of the high rotational speed possible, there was no chatter, and the effect of the impact shock was reduced.

Similar tool geometry gave good results on a lathe, when turning a 6-in. square forging to a 4-in. diameter cylinder.

All operations have been performed without coolant to avoid the harmful effect of intermittent heating and cooling on the carbide. The following conclusions can be drawn from the results of this development work:

1. The same tool geometry is suitable for heat-treated and dead-soft material.

2. The grade of carbide is not of primary importance, although longer tool life has been obtained with the titanium grades.

3. Cutting speeds from 100 to 630 ft. per min. are satisfactory. Maximum tool life is obtained at about 200 ft. per min.

4. A tool of this form can be stalled in the cut without breaking the carbide, when this tool geometry is used.

5. Absolute rigidity of the tool or workpiece is not essential. Deflection will not result in carbide breakage, but there must be sufficient support to permit a cutting action.

PHILIPS THERMOCOUPLE WIRE. A new form of thermocouple wire is now being marketed by Philips Electrical, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. Four different types are available, to cover a temperature range from −200 up to +1,000 deg. C., with a ceramic-packed single or double core, in metal sheathing. Diameters vary from 0·5 mm. to 1 mm. according to type of wire.

The wire can be bent to a curve with a radius of only five times the sheath diameter, and into any configuration without risk of earthing or shorting the cores. It has low heat capacitance at the hot junction, so that response sensitivity is high. Suitable for use under high-pressure conditions, it requires no additional insulation. It is said to be simple to install and to be very suitable for multi-point measurement where space is limited.

5th EUROPEAN MACHINE TOOL EXHIBITION, HANOVER

Thirteenth Article

LEIFELD FLOW-TURNING LATHES

An example from the range of flow-turning lathes built by Leifeld & Co., Ahlen, West Germany (Embassy Machine & Tool Co., Ltd., 248 Watford Way, London, N.W.4), is shown in Fig. 1. Known as the ST 500 H, it is the larger of two similar machines and will produce cylindrical components with diameters from 4 to 21½ in., and lengths up to 30 in., from blanks of 33 in. maximum diameter. The approximate thicknesses of material which can be formed on the lathe are as follows: aluminium, ½ in.; deep drawing sheet steel, ⅜in., and stainless steel, ¼ in. A range of nine speeds, from 52 to 890 r.p.m., is provided for the spindle, which is driven by a motor of 19 h.p., and there are steplessly-variable feeds up to 135 in. per min. for the carriage, on which the forming rolls are mounted. Inside the hollow spindle there is a hydraulic ejector cylinder, whereby the formed component can be pushed off the chuck at the end of the operation. A hydraulic pump, driven by a motor of 7½ h.p., supplies pressure oil for this ejector, also for the tailstock, pressure rolls, and carriage feed motion.

The cross-slide is mounted on the carriage so that it can float in a transverse direction, and it carries a buttress member at the rear, with a vertical face on which are mounted two housings for the spindles of support rollers. These rollers take the pressure exerted by the forming roller, and excessive loads on the spindle bearings and the bed-ways are avoided. At the front of the slide, there is a housing for a large, horizontally-mounted, hydraulic cylinder. On the ram of this cylinder is carried a mounting bracket for the roller whereby the metal of the blank, which may be circular or cup-shaped, is deformed. The wall thickness of the finished part is adjusted by means of a graduated handwheel on the side of the cylinder housing.

The Leifeld lathe was originally developed for the production of thick-bottomed cooking utensils with thin walls, but the machine is now being employed, for example, for flow-turning projectile and gas turbine components, and high-pressure bottles. All the movements are controlled by means of push-buttons, conveniently grouped on a panel on the tailstock casting. If required, the machine can be supplied with programme control equipment whereby the operation cycle can be completed automatically, when long production runs are required. Examples of parts which can be flow-turned on this lathe are seen in the foreground, also on one of the carriage projections in Fig. 1.

Another lathe in the Leifeld range, shown in Fig. 2, is intended for producing, by the spinning process, such parts as large reflectors, of the type seen in position on the chuck. A similar reflector

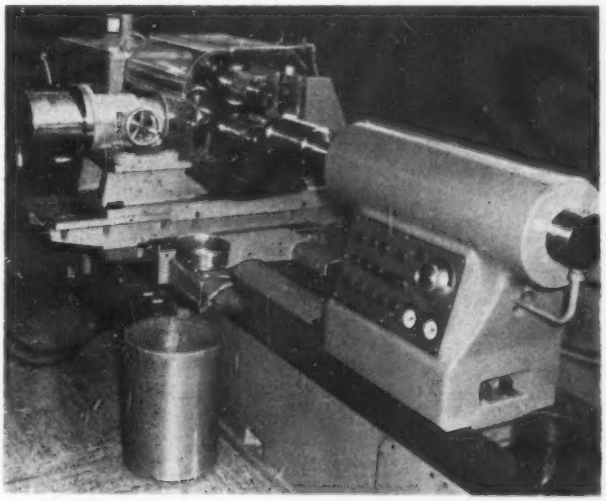


Fig. 1. Leifeld ST 500 H Flow-turning Lathe for the Production of Cylindrical Thin-walled Components from Disc- or Cup-shaped Blanks. The Machine May be Supplied with Automatic Programme-control Equipment if Required

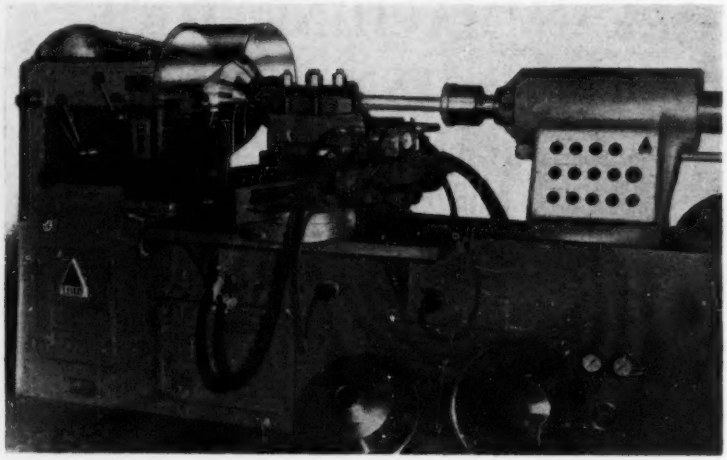


Fig. 2. On this Leifeld Spinning Lathe, Pressure is Applied to the Roller Tool by a Hydraulic Cylinder so that a Constant Thrust may be Maintained when Producing Parts of Non-circular Form

is seen in front of the machine, together with a blank, which has been pre-formed by pressing.

A guide member is mounted on a pedestal which, in turn, is supported by a substantial bracket at the front of the machine. This guide member can be set at any angle in relation to the spindle axis, and carries a tool-slide which can be traversed hydraulically at steplessly-variable feed rates. The tool-slide incorporates a horizontal hydraulic cylinder, and there is provision for clamping a tool-holder on the flat top surface. Normally, the tool bar has a forked end, and carries a roller of a shape to suit the operation to be performed. Pressure applied to the tool-slide, to thrust the roller against the work material, can be set to a maximum, so that the roller will automatically follow the contours of the chuck, and an approximately constant wall thickness will be obtained. Alternatively, the pressure, which is shown on a dial at the end of the slide, may be varied, by means of an adjacent lever. When it is required to spin a part of oval or other non-circular form, the maximum pressure required is determined experimentally, and the pressure relief valve set accordingly. Equipment can also be supplied for such operations as curling, beading, necking, bulging, and planishing.

SET-UPS ON DIEDESHEIM MACHINES

Among recent interesting developments by the German firm of Maschinenfabrik Diedesheim G.m.b.H. (Sykes Machine Tool Co., Ltd., The Hythe, Staines, Middlesex), is the automatic loading equipment fitted to the Frontomat ST 1 KS

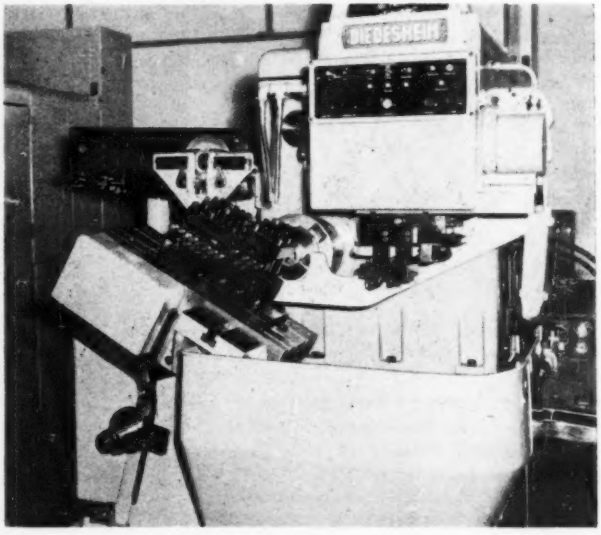


Fig. 3. For Automatic Loading and Unloading on this Diedesheim Frontomat Multi-tool Lathe, Two Arms are Employed, One with Hydraulically-operated Fingers and the Other with a Simple Curved Channel to Receive the Workpiece

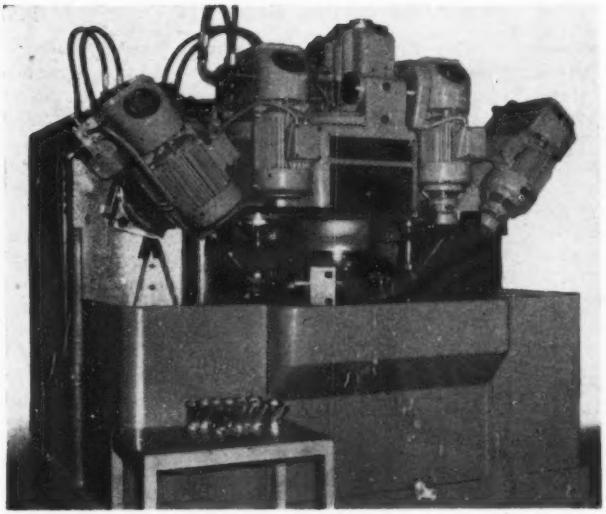


Fig. 4. Diedesheim Machine for Performing a Maximum of Nine Operations on Valve Bodies and Taps. Components are Carried to Three Machining Stations by an Indexing Fixture

multi-tool lathe shown in Fig. 3. The machine is tooled for a simple series of operations on a forged steel gear blank, of approximately 5½ in. diameter by 2⅝ in. thick (at the central boss).

At the left-hand side of the machine there is an inclined magazine, with an open-topped channel in which blanks may be placed by hand. Alternatively, where a number of operations is to be carried out in succession on different machines, an automatic elevator-type conveyor can be provided to transfer work from the discharge chute of one machine to the magazine of the next. Loading is completely automatic, and is carried out by means of a short arm, equipped with hydraulically-powered clamping fingers. This arm is carried on the end of a shaft which extends from a housing on the left at the front of the machine. Provision is made for moving the shaft through a short distance axially, and turning it through an arc of slightly more than 90 deg.

With the chuck empty, and the tools in the withdrawn position, the loading arm, which can be seen at the left in Fig. 3, is moved towards the magazine by the axial movement of the shaft, until the fingers embrace the projecting boss of the component. The fingers are then closed to grip the boss, after which the shaft is retracted to withdraw the blank from the magazine. Next, the shaft is turned, to carry the blank to a position in front of the chuck, and is moved axially, to bring the forging between the chuck jaws, against the pressure of a spring-loaded plate. After the jaws have closed to clamp the part, the fingers of the loading arm are released when the shaft is moved axially and then turned slightly, to carry it clear of the work. Subsequently, the tools carried on the inclined and overhead slides are advanced to face the boss and the side of the blank, also to turn and chamfer the boss. A spindle speed of 540 r.p.m. and a feed rate of 0·0047 in. per rev. are employed for these operations, which are performed with carbide tools.

After the machining cycle has been completed, the tools are withdrawn, and the blank is unloaded by means of a long arm, hinged in a bracket at the right-hand side of the machine. This arm, which is seen in position in front of the chuck ready to receive the component, is moved about its hinge point by the hydraulic cylinder on the right. The end of the arm which is moved into position beneath the chuck has a curved channel-section portion, and, when the chuck jaws are opened, the blank is pushed out by the spring-loaded plate, so that it falls into the channel. Then, the arm is lowered until the blank is positioned above a downwardly-inclined unloading chute, into which it rolls. Including loading and unloading, the complete machining cycle occupies a period of 54 sec. In addition to the multi-tool arrangements shown, the Frontomat machine may be supplied with copying equipment for the control of the front inclined slide, and with punched card programme control equipment.

The special machine shown in Fig. 4 is designed for operations on valve bodies, taps and similar fittings. Designated AM1, it is arranged to machine, automatically, a maximum of three openings, or sides, of such components, in sizes from ⅜ to 1¼ in. As many as nine different operations may be performed during the cycle, including drilling, turning, forming, counter-boring and threading. The machine has a central indexing fixture with four sets of hydraulically-operated jaws, spaced 90 deg. apart, the jaws being shaped to suit the particular component to be machined. This fixture indexes in a clockwise direction, as viewed from above, on a vertical axis, and the front station, at which the jaws are opened by means of a pedal at floor level, is employed for loading. Some of

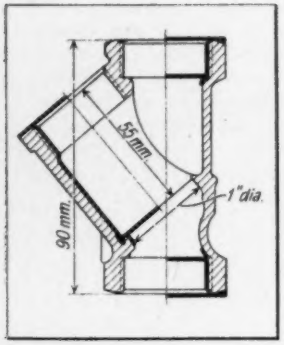


Fig. 5. Sectional View of a Typical Valve Body Showing the Surfaces Machined with the Set-up in Fig. 4 in a Cycle Time of 9 sec. For the Recessed Portion of the Inclined Bore a Retractable Tool is Employed

the valve bodies machined with the set-up illustrated may be seen on the table at the left, a sectional view indicating the surfaces on which operations are performed is given in Fig. 5. The brass castings are loaded with the main bore in a vertical position, and the inclined bore facing outwards and upwards towards the operator.

At the first machining position, on the left, there are three heads, the spindle of the upper vertical head being equipped with three tools, for boring, facing, and chamfering the upper end of the main bore. Two tools on the spindle of the inclined head at this station provide for boring and facing the inclined branch, and a head, in an inverted position beneath the fixture, is tooled for facing and chamfering the lower end of the main bore. The second indexing motion of the fixture carries the work to the rear position, and, here, there is a single inclined head for operations on the angular bore. This head carries a tool which enters the mouth of the bore—machined at the first station—in a retracted position. The tool is then automatically moved outwards for machining the larger diameter of the bore, and it is also employed for finishing the adjacent 1-in. diameter bore. At the third machining station, at the right in Fig. 4, threads are cut in the three bores with solid taps, each head being arranged for spindle reversal at the end of the stroke. The cycle time for these operations is 9 sec.

V.W.F. DIE CASTING MACHINES

Die casting machines made by Vereinigte Werkzeugmaschinen A.-G., Frankfurt-on-Main, include both hot- and cold-chamber types, one of the latter having a vertical injection plunger. Machines with die locking forces up to 800 metric tons are made for cold-chamber operation, and one of the larger sizes in the range is shown in Fig. 6. Die locking on these machines is effected by double toggle levers, operated by an oil-hydraulic cylinder, and the toggle hinge pins, of nitrided steel, operate in hardened bushes. On the larger machines, the moving platens have extensions which rest on machined surfaces on the bed, to provide additional support for heavy dies. Adjustment of the tie bar nuts, at the end adjacent to the fixed platen, is performed mechanically. The nuts have worm teeth, which are engaged by worms on shafts driven from a small electric motor on the rear face of the platen. All the nuts are thus turned simultaneously, and accurate adjustment of the platen position is quickly obtained. A handwheel, seen on the right of the operator in Fig. 6, is also geared to the motor-driven shafts, and provides for fine adjustments.

Hydraulic power for the various movements is provided by a pump unit housed in the machine base, and an accumulator system. Telescopic tubes are provided for connection to core-pulling cylinders, and on the larger machines two sets of cores may be independently operated. The automatic cycle of the machine is controlled by a camshaft, which operates hydraulic valves associated with the various cylinders, and, during setting, this cam-

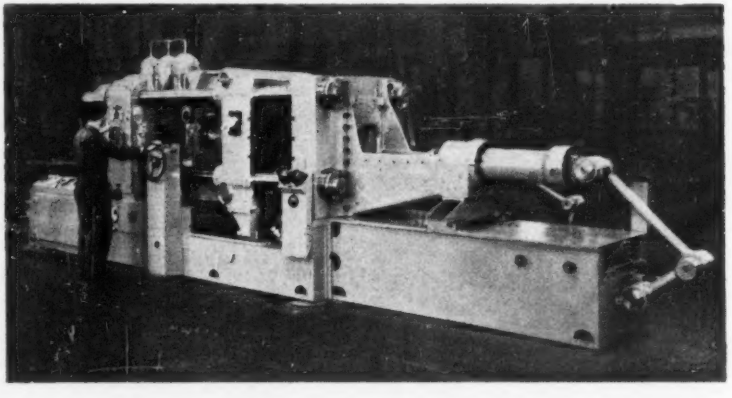


Fig. 6. On this V.W.F. Cold Chamber Die Casting Machine of 630 tons Capacity the Die Nuts are Simultaneously Adjusted, and the Fixed Platen may be Retracted for Ease in Installing and Removing Dies

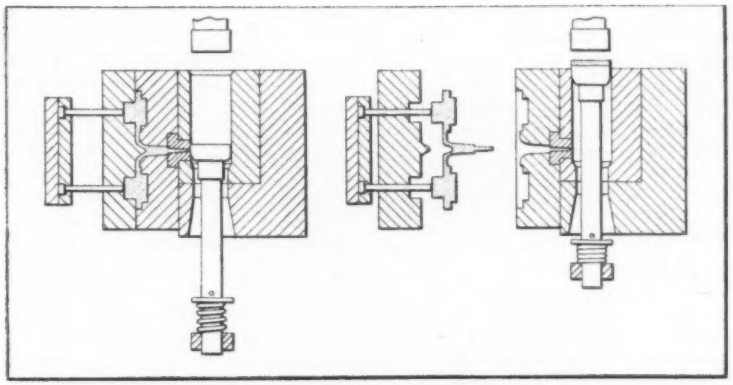


Fig. 7. When the Injection Plunger is Arranged in a Vertical Position, a Mushroom-headed Ram is Fitted in the Sleeve to Close the Sprue Orifice During Filling, and to Eject the Slug when the Plunger is Withdrawn

shaft may be turned by hand. When casting is in progress, the camshaft is driven by an electric motor, through change gears, and is controlled by a timing unit which gives the required plunger-dwell and cooling periods during the cycle. Ejector pins may be operated mechanically, or by means of the hydraulic ejector cylinder fitted to the rear of the moving platen. This cylinder may be arranged to operate four widely-spaced ejector bars when the central portion of the die is occupied by a core-pulling cylinder. The sequence of operations of the die-closing mechanism, the core-pulling cylinders, and the hydraulic ejector cylinder are electrically interlocked, by means of limit switches, so that each movement must be completed before the next can start.

At the right-hand end of the machine in Fig. 6, beneath the injector plunger, and secured to a machined end face of the bed, is a substantial box-shaped extension casting with flat ways on its upper surface. A bridge member carried on these ways supports the plunger housing, and this housing is connected to the ram of a hydraulic cylinder inside the bed extension. When a large and heavy die, such as is normally employed on a machine of this size, is to be changed, the clamps securing the moving half of the die to the moving platen, together with the tie-bar nuts which hold the fixed platen in place, are removed. By operation of the cylinder inside the bed extension, the fixed platen can then be retracted, together with the complete die. In this position, the die can conveniently be removed, and another fitted. Pressure oil is supplied to the injection plunger cylinder through a pipe with an articulated joint, and the hydraulic system need not be uncoupled when die changing is carried out in the manner described.

The injection arrangements on the hot-chamber machines, and on the cold-chamber machines with horizontal plungers, are conventional. For the cold-chamber machine which has a vertical injection plunger, the system shown diagrammatically in Fig. 7 is employed. Here, the plunger is seen above the sleeve, which is housed in the fixed platen. The lower end of the sleeve is of reduced diameter and accommodates the mushroom head of a ram, which is spring-loaded so that its top surface is normally above the level of the gate leading to the casting cavity. This opening is thus closed off while the metal is poured into the sleeve. When the injection stroke takes place, the plunger pushes down on the metal in the sleeve, and the lower ram is thrust down until the opening leading to the cavity is uncovered and the metal can flow into the die. After the metal has solidified, and the plunger has been withdrawn, the ram is moved upwards, shearing the plug from the sprue and carrying it upwards to a position above the top of the sleeve, whence it may readily be removed. It is claimed that, with a vertical injection plunger, apart from the fact that floor space is saved, the area of metal exposed to oxidation in the sleeve is considerably less than with a horizontal arrangement.

Among the features of the hot-chamber range of die casting machines is the method employed for withdrawing the nozzle of the goose-neck from the die after each shot has been made. The furnace, with its associated injection equipment, is mounted on floor-level rails attached to the end of the machine bed, and there are two hydraulic cylinders at the top. The rams of these cylinders are connected to the fixed platen, and the cycle control equipment provides for automatic movement of the furnace into engagement with the die when a shot is to be made, and automatic withdrawal immediately after the casting has solidified. In this way, heat transfer from the goose-neck is kept to a minimum. Where casting is to be carried out at such a high rate that insufficient time is available

for moving the furnace, the hydraulic cylinders can be disconnected from the circuit by altering the setting of a valve. Hot-chamber machines are made in two sizes, with die locking forces of 50 and 100 tons. In addition, the company make injection moulding machines with the same locking forces, and these machines, also, have provision for hydraulic operation of cores.

MARIANI FLYING SHEARS FOR ROLLED SECTIONS

A flying shear, for cutting cold-rolled sections as they emerge from the rolls of the forming machine, has been introduced by the Italian firm of Officine Meccaniche Romildo Mariani [Cyril Adams & Co. (Special Projects), Ltd., 70-74 City Road, London, E.C.1]. Designated 163 TV, this machine is shown in Fig. 8, and the design is generally similar to that of a conventional dieing press. Alternatively, the machine may be employed as a dieing press when suitable strip-feeding units are fitted. For use as a flying shear, the machine is equipped with tools suitable for shearing the particular section that is being rolled. These tools are mounted on slides secured to the upper and lower bolsters, and the tools travel along with the section during the cutting stroke. The tools are then retracted to the initial position, ready for the next operation, by the air cylinder at the right-hand end of the bed. Normally, an upper blade about ¼ in. thick is employed, with the corners chamfered at an angle of 45 deg. In consequence, the material that is cropped from the strip is deformed outwards, and thus is sheared more easily. The die block has guide channels conforming approximately to the section of the material to be cut, and the die itself is designed so that the rolled section is supported on three sides against the action of the cropping blade.

A run-out table is provided on the far side of the machine, and above it there is a hinged stop, which is pushed aside by the end of the section emerging from the tools. Movement of the stop operates a micro-switch, which controls an electro-pneumatic clutch whereby the upper tool is rapidly brought down to shear the work. As soon as the material is gripped between the cropping blade and the die, the complete tool begins to be moved along with the material, while the blade is still descending. At the end of the stroke of the upper bolster, the blade is retracted, and the material which has been cut off falls on to the run-out table. Then, air is immediately admitted to the ram side of the air cylinder, to move the tool back to the starting point, while the rolled section emerging from the forming machine continues to advance towards the hinged stop. A safety device is fitted, which automatically stops the forming machine should the hinged stop fail to operate the shearing unit. Sections with areas of up to 1·62 sq. in. may be sheared on the machine.

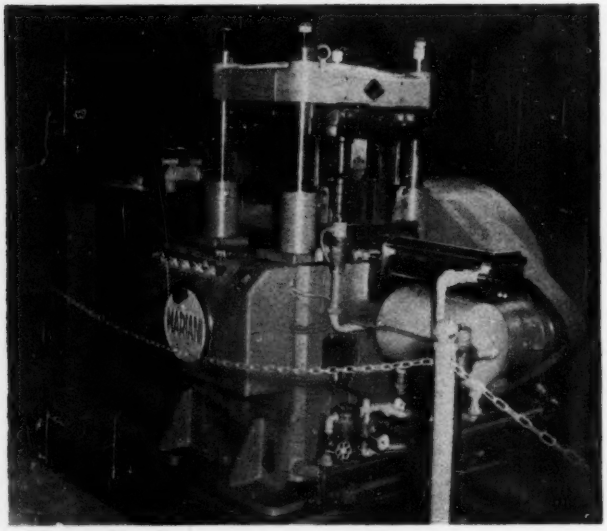


Fig. 8. Sliding Tools Moved by the Material which is being Cut are Employed on this Mariani Flying Shear for Cold-rolled Steel Sections

TRIULZI DIE CASTING MACHINES

A newly introduced cold-chamber die casting machine of 80 tons capacity, known as the Castmatic 80 T-OL, is shown in Fig. 9. Made by the Italian firm of A. Triulzi, Milan (Alexander Cardew & Co., Ltd., 2-5 Studio Place, Kinnerton Street, London, S.W.1), the machine represents a new departure for the makers, since it has a self-contained oil-hydraulic system, with a pump driven by a motor of 12 h.p., instead of the usual arrangement for using water supplied from a central pumping station. The machine is made in three sizes, with die-closing forces of 40 and 120 tons in addition to that quoted above, and a hydraulic accumulator is provided for the operation of the injection plunger.

Die closing is effected through a

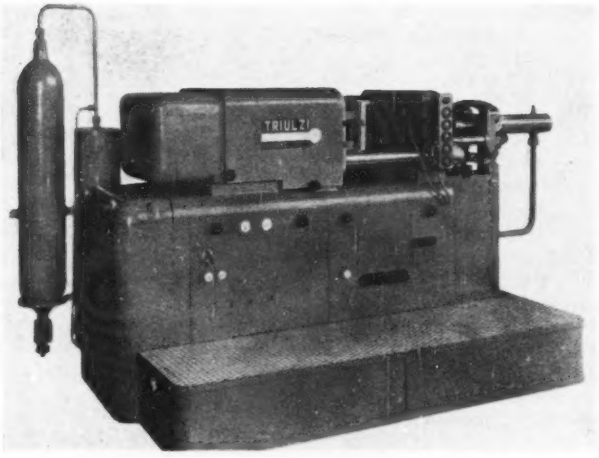


Fig. 9. Triulzi Castmatic 80 T-OL, Automatic Cold Chamber Die Casting Machine of 80 tons Capacity with Built-in Oil Hydraulic System

toggle mechanism, which gives a stroke of 11·8 in., on the machine illustrated, and the maximum and minimum distances between the platens are 23·6 and 15·75 in. Two tie bars are employed on each of the smaller machines, and four on the largest size, and on the 80-ton machine the platens measure 10 by 17 in. The machine can be operated on an entirely automatic cycle, and it is also available with the injection plunger arranged vertically for cold-chamber operation, and with a melting furnace for the hot-chamber casting of zinc.

HESSAPP VERTICAL SPINDLE LATH

A Hessapp semi-automatic vertical-spindle lathe, made by the German firm of Hessische Apparatebau, G.m.b.H., Hahn, is shown in Fig. 10, set up for machining a flange. Described originally in MACHINERY, 87/923—14/10/55, in connection with the Third European Machine Tool Exhibition, these lathes can be supplied, with a maximum of four horizontal or vertical slides, for operations on components up to 9½ in. diameter. On the machine illustrated, there is a horizontal slide at the right, and a horizontal slide at the left, which carries a vertical slide. In place of the tailstock, a newly-introduced multi-spindle drilling attachment is mounted above the spindle. This attachment can be provided with a maximum of six spindles, which are driven through planetary gearing when the head is moved downwards and engaged with the machine spindle. For the set-up shown, only two spindles are required, for drilling holes of approximately ¼ in. diameter in opposite sides of the flange, the component being held in a 3-jaw hydraulically-operated chuck.

Three tools carried by the compound slide at the left are first moved to the right, and then are fed downwards for boring, counter-boring and chamfering the workpiece. Next, the right-hand horizontal slide of the lathe is advanced, to machine two faces at different levels, and, after the slide has been withdrawn, the spindle is automatically arrested in the correct radial position, as indicated, so that the drilling head can be engaged with the spindle. Drive to the spindle is then re-started, and the drilling operation is completed. The turning and boring operations are carried out at a spindle speed of 200 r.p.m., with a feed of approximately 0·009 in. per rev.

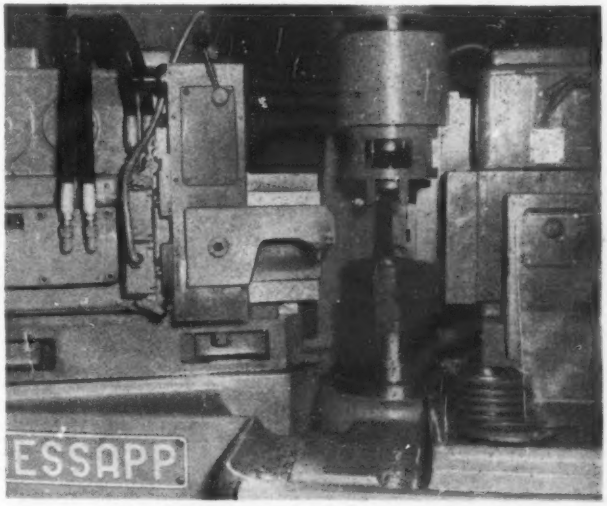


Fig. 10. Close-up View of a Hessapp Vertical Spindle Lathe, Set Up for Boring, Counter-boring, Facing, and Drilling Operations on a Flange

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MINGANTI RIM.9 INTERNAL GRINDING MACHINE FOR DIESEL INJECTOR NOZZLES

The Minganti [Cyril Adams & Co. (Special Projects), Ltd., 70-74 City Road, London, E.C.1], RIM.9 internal grinding machine, shown in Fig. 11, has been developed from the company's precision internal grinder, of the same designation, specially for the purpose of grinding the cylindrical and the conical seating portions of diesel engine injector nozzles.

On this machine, two wheel-heads are carried on a bridge member, and have spindles which form the armatures of motors supplied with high frequency current by the converter at the right. These spindles can be driven at speeds of up to 90,000 r.p.m., which is employed for cylindrical grinding, and the front spindle is mounted with its axis parallel to that of the workhead. The other spindle is mounted on guideways in a cradle, which can be adjusted so that the spindle axis is at an angle up to 30 deg. relative to the workhead, and this spindle is employed for grinding the conical seat.

The workhead spindle, in which the nozzles are held in a hydraulically-operated collet chuck, is driven at speeds of 420, 660 or 920 r.p.m., and the slide on which it is mounted can be reciprocated automatically during the cylindrical grinding operation on the nozzle. The slide is then fixed in position, and the second grinding spindle is brought into use for finishing the nozzle seating.

Provision is made for dressing both grinding wheels, and for their adjustment relative to the workhead axis to compensate for the material removed. Nozzles with inside diameters of 3 to 40 mm. can be ground on the machine, and a coolant system is provided.

BECKER & VAN HULLEN METAL POWDER PRESSES

The range of hydraulic presses built by the German firm of Becker & Van Hullen, Crefeld [Arpal (Engineers), Ltd., Abford House, Wilton Road, London, S.W.1], includes machines for the production of components from metal powder. One of these presses, which are made in sizes capable of exerting forces from 2½ to 100 metric tons, is seen in Fig. 12. Intended for the production of tool bits, among other components, the press has an upper and a lower hydraulic cylinder, between which there is a table to support the mould. A third, horizontal, cylinder on the table operates the filling mechanism, and moves the completed pressings clear of the cavity when they are ejected by the lower cylinder ram.

Pressure oil for the operation of the cylinders is supplied by a pump of the multiple-plunger type, and the pressing cylinders may be controlled by a hand lever, or semi-or fully-automatically. Timing equipment is provided, so that the pressure may be maintained for a pre-set period after the powder has been compacted, and the press may be operated on a fully-automatic cycle.

During the cycle, the cavity is first filled by a forward stroke of the small horizontal cylinder, the ram of this cylinder being fitted with a metering unit which is replenished from a hopper. After the filling unit has been withdrawn, the upper cylinder ram is brought down to close the cavity, from above, and, at the end of its travel, it operates either a pressure- or a motion-sensitive switch. As a result, the upward movement of the lower ram is started, and, when it has completed its stroke, another switch is operated to energize the time delay unit. At the expiry of the pre-set period, the upper ram is raised, and the lower ram also rises to eject

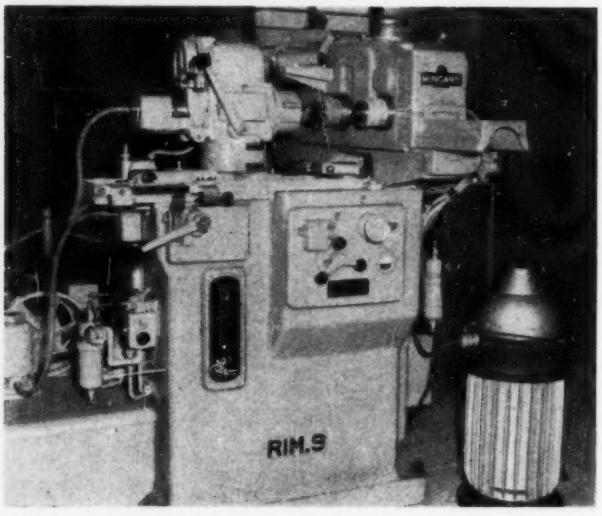


Fig. 11. Minganti RIM.9 Internal Grinding Machine for Operations on Cylindrical Bores and Conical Seatings in Diesel Engine Injector Nozzles

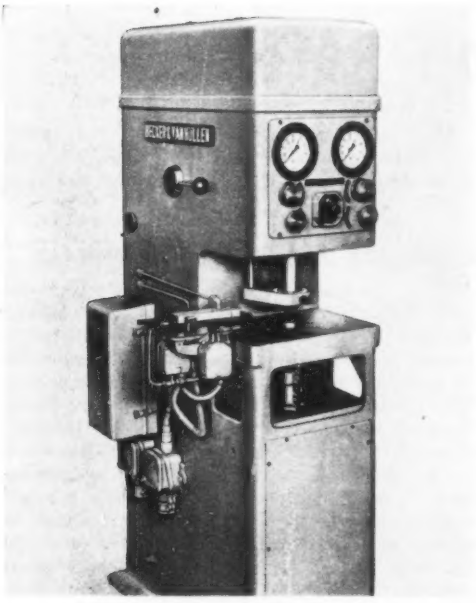


Fig. 12. Becker & Van Hullen Powder Metal Press, with Upper and Lower Hydraulic Compacting Cylinders. A Third Horizontally-disposed Cylinder on the Table Operates the Filling Mechanism, and Moves the Completed Compact Clear of the Cavity

the part. Finally, the small horizontal cylinder is again advanced, to move the ejected part clear of the tool, and refill the cavity.

A NEW ELECTRONIC TIMER has been introduced by British Oxygen Gases, Ltd., Spencer House, St. James's Place, London, S.W.1, for use with the Argonarc spot welding process. This process can be applied to the 18/8 group of stainless steels, and to some of the new high-tensile stainless steels, including FV 520 and FSM1.

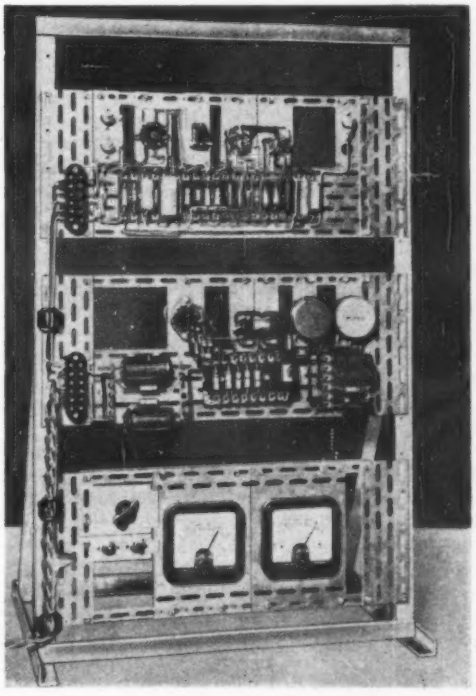
Formerly, a condenser relay timer was used to determine the duration of the welding period, and an electro-mechanical process timer controlled the flow of argon which is used to cool the weld and prevent surface cratering and cracking in the fused zone. With the new unit, both timing cycles are accomplished by one electronic valve. The circuit can now be more easily serviced, and the unit, which is mounted on the spot welding cabinet, is smaller and lighter than that originally employed.

Rapikon Electronic Chassis Assembly Systems

The Rapikon system of electronic chassis construction has been developed by Shandon Electronics, Ltd., 6 Cromwell Place, London, S.W.7, an associate company of Shandon Scientific Co. Ltd.

This system provides for the rapid construction of experimental chassis from a range of standard slotted plates and angles. As may be seen from the illustration, an angle-iron frame serves to hold the slotted plates which, in turn, receive holder plates specially punched to suit standard units such as valve-holders, potentiometers and switches. Extra circuits can be added and quickly connected to those already in position on the frame. A screwdriver only is required to assemble any of the Rapikon parts.

It is claimed that a considerable amount of time can be saved with this system when experimental circuits have to be assembled and proved, as additions and modifications can be made rapidly and easily.



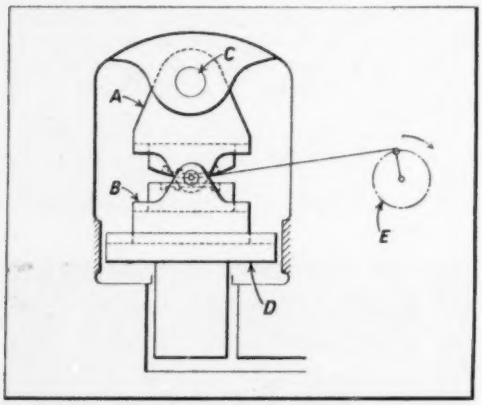
Rapikon Bench Frame with Holder Plates and Electrical Components Assembled

Machine Shop Patents

A FORGING PRESS WITH SWINGING AND SLIDING DIE HOLDERS

In the figure is shown, diagrammatically, part of a forging press which incorporates a swinging holder *A* for the upper die, and a sliding holder *B* for the lower die.

The holder *A* can be pivoted about the cross



Part of a Forging Press with Swinging and Sliding Holders for the Upper and Lower Dies Respectively

pin *C*, and the associated die has a cavity that is formed at right angles to its arcuate lower surface. The holder *B* is arranged to slide in guideways in the table *D*, which can be adjusted vertically. Drive to both holders is taken from a single crank disc, indicated at *E*, through separate connecting rods, so that similar speeds are obtained at the opposing faces of the dies.

In operation, a heated blank is loaded on to the lower die, and the table *D* is then moved upwards until the blank is gripped lightly between the tools. Next, the drive to the crank disc *E* is started, and during the forging operation, the table *D* is moved upwards intermittently, so that the metal is caused to flow into the die cavities.

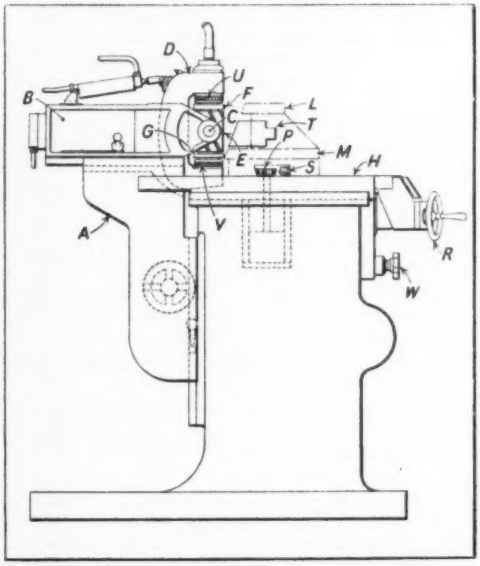
Since forging is carried out progressively, and pressure is applied to only a small area of the work at any point in the working cycle, relatively small loads are imposed on the moving parts of the press. In consequence, the machine need be of only light construction.

785,722. Beche & Grohs G.m.b.H., 31, Peterstrasse Huckeswagen/Rhineland, Germany. [*Application dated April 4, 1955. Published November 6, 1957.*]

MACHINE FOR CONTOUR-MILLING CHAMFERED EDGES

The side elevation of a contour-milling machine, arranged for direct copying from templates, is shown in the accompanying drawing. The vertically movable member *A* carries guideways for the cutter slide *B*, which, in turn, supports the pivots *C* for the tilting cutter head *D*. A milling cutter *E* is mounted on a vertical spindle, which is driven through a flexible shaft. The ball bearings *F* and *G* are mounted on the sleeves *U* and *V*, which are eccentric in relation to the spindle and can be adjusted independently of the latter.

A table *H* can be moved horizontally along guideways provided on the top of the main base, and clamped as required. The table *H* supports a fixture *K*, which carries the two templates *L* and *M*, and the fixture can be traversed across the face



Side Elevation of a Template-controlled Milling Machine

of the cutter by means of a friction roller *P*, driven from an epicyclic gearbox and electric motor housed in the machine base. A pair of pivoting tension rollers *S* is carried on a spring-loaded shaft, and serves to maintain the fixture *K* in contact with the roller *P*. Hand traverse of the fixture, on the table *H*, is provided by the hand-wheel *R*.

In operation, the table *H* is fed forward until the template *M* makes contact with the ball bearing *G*. Further forward movement of the table then causes the cutter head *D* to pivot about the bearings *C*, until the ball bearing *F* makes contact with the template *L*. The fixture, holding the workpiece *T*, is now fed past the cutter, and the cutter head *D* will tilt, and the fixture will pivot, in accordance with the form of the templates *L* and *M*. Various depths of cut can be set by adjusting the eccentric sleeves *U* and *V*, which will advance and retract the bearings *F* and *G* in relation to the cutter, graduated collars being provided to facilitate this adjustment.

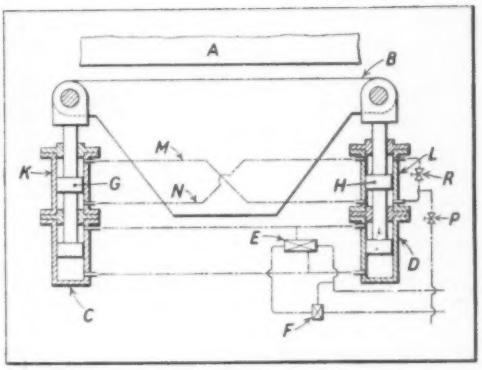
In normal operation, the outer casing of the epicyclic gearbox, which drives the friction roller *P*, is held stationary by a band brake. Control of this brake is provided by the hand-wheel *W*, and variations of the feed rate can be obtained by allowing the brake to slip. A hydraulic, or pneumatic, ram connects the cutter slide *B* and the cutter head *D*, and manual control of this ram allows the cutter head to be tilted to any desired angle, independently of the templates.

785,548. Westland Aircraft, Ltd., Yeovil, Somerset. (*Application date, December* 8, 1954. *Published October* 30, 1957.)

HYDRAULIC BALANCING ARRANGEMENT FOR TWIN-CYLINDER OPERATED MACHINES

A means of compensating for the tendency of one of a pair of tandem hydraulic rams to move in advance of the other, when an out-of-centre resistance is encountered, is shown in the accompanying illustration. An up-stroking twin-cylinder hydraulic press is taken as an example, the fixed member of the press being shown at *A*, and the moving member at *B*. The cylinders *C* and *D* are connected, in the normal manner, and are supplied with hydraulic pressure oil through a conventional reversing valve *E*, and a relief valve *F*.

The cylinders *K* and *L* are secured to the cylinders *C* and *D*, and the former house the pistons *G* and *H*, which are fixed to the common piston-rods. Separating seals are provided between the connecting flanges of each pair of cylinders, and these are also arranged to form sliding-seals for the piston-rods.



Hydraulic Balancing Arrangement for Twin-cylinder Operated Machines

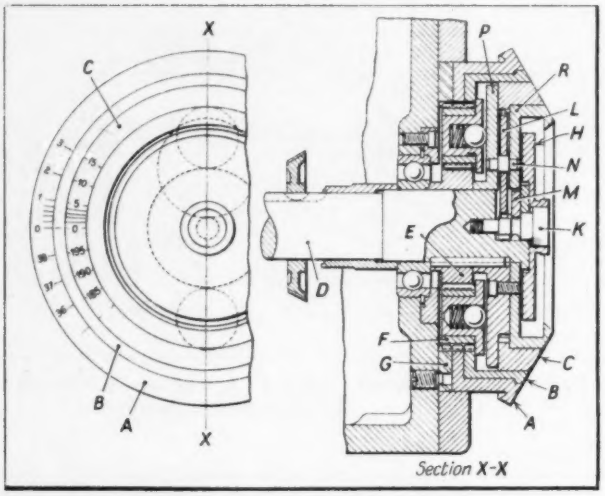
The lower and upper-compartments of the cylinders *K* and *L* are inter-connected, by means of the pipes *M* and *N*. A closed-circuit is thus provided between the cylinders *K* and *L*, and a branch pipe is taken from the main hydraulic pressure line to charge these two cylinders. A nominal pressure in this closed-circuit is controlled by means of the secondary relief valves *P* and *R*, and these valves incorporate a means of shutting-off the main supply when the cylinders *K* and *L* have been charged to the required pressure.

When the member *B* is raised, the oil in the cylinders *K* and *L* is interchanged through the pipes *M* and *N*. In operation, any unequal distribution of resistance to the member *B* may cause, say, the piston *H* to move in advance of the piston *G*. When the piston *H* advances in this manner, however, the pressure of the hydraulic oil in the upper-compartment of the cylinder *L* will increase. Owing to the fact that this compartment is connected to the lower compartment of the cylinder *K*, this increased pressure is transmitted to the underside of the piston *G*, and the relative position of the piston rods is restored.

785,540. Thomas Campbell, 75 Nevis Avenue, Belfast, Northern Ireland. (*Application date, March* 14, 1953. *Published October* 30, 1957.)

POSITIONAL INDICATOR AND VERNIER FOR MACHINE TOOL SLIDES

Sectional and end views of a displacement indicator are shown in the accompanying drawings. Basically, the indicator consists of a scale-dial *A*, a zero-dial *B*, and a vernier-dial *C*, these dials being arranged concentrically. The dial *A* is driven in relation to the machine slide concerned; the dial



Sectional and End Views of a Positional Indicator for Machine Tool Slides

B remains stationary under all conditions; and the vernier-dial *C* is rotated simultaneously with the shaft *D*, but can also be adjusted independently.

Graduations on the dial *A* indicate, in inches, the total travel of the machine slide, these divisions being sub-divided to 0·2 in. The dial *C* has 200 divisions, and indicates the slide movements to 0·001. The shaft *D* is driven from the slide traverse screw through bevel gears, and by means of the sun-pinion *E*, the planet gears *F*, and the fixed internal gear *G*, rotates the dial *A* through one complete revolution for each full traverse of the slide. This slow-speed rotation is obtained by arranging for the number of teeth in the bore of the dial *A* to be greater, by at least one, than the number of internal teeth in the gear *G*.

The zero-mark dial *B* has the same number of teeth as the gear *G*, and also meshes with the pinions *F*. Rotation of the sun-pinion *E*, therefore, cannot cause any rotation of the dial *B*.

A counter-weight disc *H* is attached to a stub-shaft *K*, which is free to rotate in the shaft *D*, and has integral teeth meshing with the idler gear *L*. This latter gear is carried on a spindle *N*, between the parts *P* and *R*, and meshes with internal teeth in the bore of the vernier-dial *C*. The parts *P* and *R* are keyed to the shaft *D*, so that rotation of the latter will turn the dial *C*, through the positive connection afforded by the gear *L*. For setting, the dial *C* can be rotated, independently of the shaft *D*, by manually turning the knob portion of the disc *H*, attached to the shaft *K*.

In operation, therefore, the vernier dial *C* rotates at the same speed, and in the same direction, as the shaft *D*, while the dial *A* moves angularly through only one of its minor graduations for each complete revolution of the dial *C*. In the event of sudden deceleration of the shaft *D*, the dial *C* will tend to over-run, and such movement would disturb its setting relative to the dial *A*. However, in these circumstances, the counter-weight *H*, and the shaft *K*, will also tend to over-run, and any such movement would tend to turn the dial *C*, by means of the idler-gear *L*, in the opposite direction. It is arranged that the moments of inertia of the dial *C*, and the disc *H*, are in the same ratio as the teeth on the shaft *K* and the dial *C*. Consequently, the moments of inertia of the parts *C* and *H* oppose, and counterbalance, each other. The dial *C* is thus decelerated at the same rate as the shaft *D*, and the angular relationship is not disturbed.

Sudden acceleration of the shaft *D* is compensated in the same manner. Spring-loaded balls, within the pinions *F*, serve to locate the assembly axially against the inner face of the dial *B* and the flanged end of the shaft *D*.

785,245. Giddings & Lewis Machine Tool Co., Wisconsin, U.S.A. [*Application date, July* 28, 1954. *Published, October* 23, 1957.]

EXPENDABLE CONTAINERS FOR COILED STEEL WIRE.—High-carbon steel wire is now being transported in an economical fibre drum, with an inner bag made from polyethylene, supplied by the Plastics Division of the Union Carbide International Co., 30 East 42nd Street, New York, U.S.A. Hitherto, coils of wire were individually spirally-wrapped in paper, and transported in returnable wooden barrels, and the new expendable containers have resulted in a reduction of transport costs.

The polyethylene liner protects the wire against rust and corrosion, and prevents the transfer of oil from the coil to the outer casing. Oil would soften the casing, so that small pieces of fibre might become loosened, and mix with the wire, with the result that the equipment for forming the wire might be jammed. As the wire is used, the liners can be employed for other purposes.

Turbine Blades Reclaimed by Electrolytic Grinding

By E. W. DENISON* and C. V. RUEHRWEIN*

Fluorescent penetrant inspection of turbine blades for jet propulsion units produced at the Evendale, Ohio, works of the General Electric Co., U.S.A., showed that a considerable number had cracks on the root flat of the dovetail. Sample blades were sectioned, and analysed metallurgically to determine the nature and extent of the damage. Cracks 0·003 to 0·020 in. deep in the highly stressed surface were thus revealed. This damage had been caused by abnormally severe grinding conditions, involving rapid stock removal with insufficient coolant.

If these blades had all been scrapped there would have been a heavy loss, since they were made from an expensive material, and considerable labour had been involved in their production.

Examination of the rejected blades showed that 0·005 to 0·010 in. of stock could be removed from the cracked surfaces without departing from the dimensional tolerances. Attempts were first made to remove the cracked surface material by conventional grinding operations, with various feeds and speeds.

Grinding wheels and coolants were changed, and abrasive belts were also tried; but, invariably, the effect was to extend the cracks. It was obvious, therefore, that each attempt merely extended the damage to the already highly-stressed surfaces of the blades, and that the material could only be removed successfully by some method which would not induce additional stresses.

Recently, a surface grinder was purchased to enable the electrolytic grinding process to be investigated as a possible means of overcoming certain difficult manufacturing problems. The electrolytic grinding equipment, shown in the figure, consists of a DoAll surface grinder and Anocut electronic control equipment. To adapt this grinder to the Anocut electrolytic process, the wheel-spindle was insulated from the remainder of the machine. The negative connection from the electronic control unit is made to the wheel-spindle through heavy-duty brushes, and the positive connection to the work-table.

In the Anocut process, an electrolyte replaces the usual coolant, and heavy current at low voltage serves to remove the work material. Plating of the electrode wheel with metal from the workpiece is avoided by dissolving this material, as it is removed, in the electrolyte. The metal combines with other elements present in the solution to form soluble salts. Accurate control of dimensions is obtained by contact of the workpiece with abrasive particles in the electrode wheel. The distance that these insulating abrasive grains protrude from the metal electrode wheel controls the

Experimental Set-up for Electrolytic Grinding. The Operator is Taking a ⅛-in. Cut on a Piece of Stainless-steel Honeycomb Material with a Wall Thickness of 0·002 in.

* Aircraft Gas Turbine Divisions, General Electric Co., U.S.A.

gap between the conducting portion of wheel and the work, and the action of the abrasive assists in the continuous removal of material.

Preliminary tests of the electrolytic grinding process were carried out on Type 403 stainless steel, Armco 17-7 PH and Lapelloy. Laboratory examination of the test pieces revealed no change in the hardness or the microstructure of the work-material.

Because electrolytic grinding will remove metal without inducing stresses, it was thought that the process might solve the problem of reclaiming the blades. By the use of angle-plates and C-clamps, the holding fixture from a production grinder was adapted for use on the DoAll machine. Varying depths of metal, from 0·005 to 0·010 in., were removed in one pass, at a table speed of approximately 5 in. per min. A 150-grit diamond electrode wheel, of 10 by ¾ by 3 in., was employed at a speed of 5,000 ft. per min., and the electrolyte used was a solution of Anocut E-7 salts and water.

Micro-analysis of an etched cross-section of a blade root ground by the electrolytic method showed no change in the microstructure of the surface, and it was found that the cracks had been completely removed. Inspection of the electrolytically-ground surfaces, using a fluorescent penetrant, indicated that all cracks had been eliminated, except in those blades where the damage extended below the depth to which material could be removed. These blades had to be scrapped.

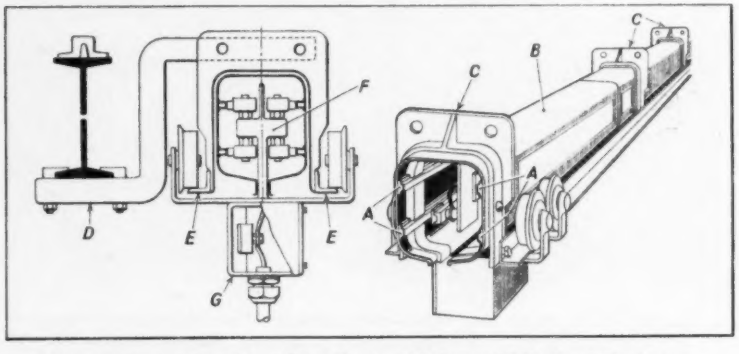
The savings obtained in labour and critical material by the use of electrolytic grinding, in this instance, almost equalled the amount spent on the experimental machine. Plans have been made to utilize this process in the grinding of metallic honeycomb, "super alloys," tungsten carbides, and other materials that present serious machining problems.

Clayton Safeguard Enclosed Conductor System

Clayton Safeguard, Ltd., Irwell Chambers East, Union Street, Liverpool, 3 (a subsidiary of the Clayton Crane & Hoist Co., Ltd.), have recently introduced an enclosed conductor system for supplying electric power to travelling machinery, such as overhead cranes. An end elevation is shown at the left-hand side of the accompanying figure, and, on the right, a length of the enclosure with an end plate removed, so that the T-section, 100-amp., busbars *A* may be observed. A collector trolley is seen at the near end of the enclosure, which is normally supplied in 12-ft. lengths, each weighing about 56 lb. These lengths are readily connected by means of bolts, to form a continuous system.

The busbars are located by Tee-slots in the saddles *C*, spaced at intervals of 4 ft. Brackets, as indicated at *D* in the drawing, which are available in a variety of types to suit requirements, support the assembly by the saddles. On each side of the saddles, rails *E* are fitted on which the 3-in. diameter wheels of the collector trolleys run. To provide clearance for the central member *F* of each collector trolley, which carries the 60-amp. collector head, there is a narrow slot at the bottom of the trunking. The collector head has four spring-loaded shoes, fitted with renewable carbon inserts, whereby current is conveyed from the busbars to the junction box *G* which is located at the base of the trolley frame.

With the rails located outside the trunking, a collector head of substantial design can be employed, and because the busbars and collector heads are fully enclosed in the trunking, apart from the narrow slot at the bottom, considerable protection is afforded against the ingress of foreign matter. It is stated that the enclosure can be employed in the open and in steamy atmospheres.



End and Perspective Views of the Clayton " Safeguard " Enclosed Conductors

New Production Equipment

Lamberton 500-ton High Speed Forging Press

The 500-ton high speed forging press built by Lamberton & Co., Ltd., Coatbridge, Scotland, has recently been the subject of some design improvements, and the latest type is shown in the figure.

A new feature is a disc-type crankshaft brake of the company's design. With this unit, rapid dissipation of heat is obtained, so that a powerful braking action and a long working life are ensured. The friction facings are bonded to steel backing plates. The entire caliper assembly is supported by two pins, one of which can be removed so that the unit can be swung clear of the disc for maintenance purposes.

The Latest Lamberton 500 Ton High-speed Forging Press

Drive to the crankshaft is transmitted by a clutch, also of the company's design, which is housed in the flywheel. This unit incorporates a back stop for controlling the stroke of the operating cylinder, and provision is made for indicating the amount of wear of the bonded friction facings. Air-operated ejectors are provided for the ram and die table. Three ejector pins can be employed in the die table, and the electro-pneumatic control system enables them to be brought into use, as required, at any point in the operating cycle of the press. The pins may be held in the raised position for a few seconds after the press has been stopped, to facilitate unloading forged components. Ejectors may be brought into use at each operating cycle of the press, or at the end of every second or third working stroke.

The frame is a rigid one-piece steel casting with shrunk-in tie bars. A load meter, with a maximum reading attachment, is provided to facilitate setting up new forging dies. When setting has been completed, the load meter may be removed from the press. Vertical adjustment of the die table is effected by a wedge, which incorporates a calibrated pointer, so that accurate settings can be readily made.

Automatic lubrication of important bearings and slideways is effected by a motorized pump, which is interlocked with the starter for the main driving motor. Provision is made for "inching" the ram in either direction. If required, automatic work transfer equipment may be fitted.

Eumuco (England), Ltd., 12 Great Portland Street, London, W.1, are the distributors for Lamberton forging presses.

Butler 36-in. Openside Crank Planer with Heid Electric Copying Unit

Fig. 1 shows a 36-in. openside crank planer of standard basic design, built by the Butler Machine Tool Co., Ltd., Halifax, which has been modified for use with Heid electrically-controlled copying equipment. The need for the normal

clutch drive has been eliminated by the provision of a pendant electric push-button switch, which gives "start," "stop" and "inch" control of the table from either side of the machine.

If ordinary planing work is to be performed, the Heid unit can be switched off, and the standard mechanical dial-operated feed to the cross-slide tool-box brought into operation. Alternatively, the copying device can be employed to provide an intermittent and steplessly-variable feed, both horizontally and vertically, without the use of a former plate.

The Heid unit is readily applied to the end of the cross-slide, the requisite alterations comprising the fitting of an adapter plate, and lengthening of the standard shaft and screw for the tool-box feed. In addition, the standard toolbox is modified by the provision of a mounting for the electric stylus. The latter is carried on a bracket and is arranged for horizontal and vertical adjustment for accurate setting in relation to the work, as shown in the close-up view at Fig. 2.

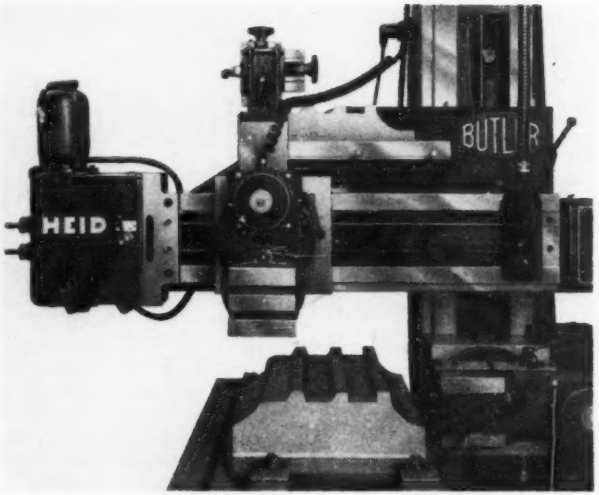


Fig. 2. Close-up View of the Cross-slide on the Butler Machine Showing the Heid Unit and Template

A test piece mounted on the table affords an indication of the angular and curved forms which can be machined. The copying system will also reproduce a vertical face, the stylus then being held in position by contacts controlling the vertical feed. No further movement takes place until an electric switch, controlled by dogs on the side of the table, is energized, and, then, the stylus and tool move vertically by the amount of the selected feed.

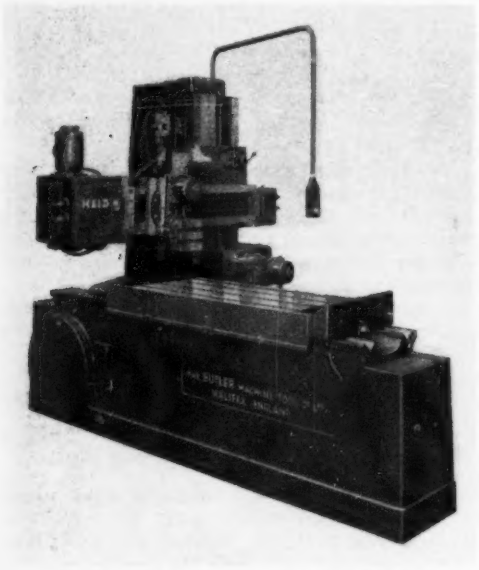


Fig. 1. Butler 36-in. Openside Crank Planer with Heid Electric Copying Unit

The Heid system embodies a high-speed motor, which runs constantly, and twin magnetic clutches mounted on the horizontal screw and shaft. The gears of the unit run in oil, and two pick-off gears are incorporated whereby the entire feed ratio may be altered, if required. A selection lever determines whether the unit is engaged, or the screw and shaft freed, for control by the normal drive.

For operation of the copying system, there is a control panel on a transportable floor-mounted desk, which can be placed in the most convenient working position. There are four buttons on the left-hand side of the panel, with signal lamps which indicate horizontal and vertical power-traverses in either direction. A switch in the centre of the panel selects "off," "planing" and "copying," and there is a second switch for "right," "left," "up," and "down" feed movement, when the unit is employed for ordinary planing. A dial above the two switches controls the steplessly-variable feed. On the right-hand side of the panel, there is an isolating switch, also a tool-lifting switch for controlling either or both toolboxes, as desired.

Colonial Horizontal Broaching Machine for Cutting Large Gears

A universal broaching machine for large gears has been developed by the Colonial Broach and Machine Co., Detroit, Michigan, U.S.A., and is shown in the accompanying figure. Either finished spur, or semi-finished helical, gears can be produced, up to a maximum pitch diameter of 42 in.

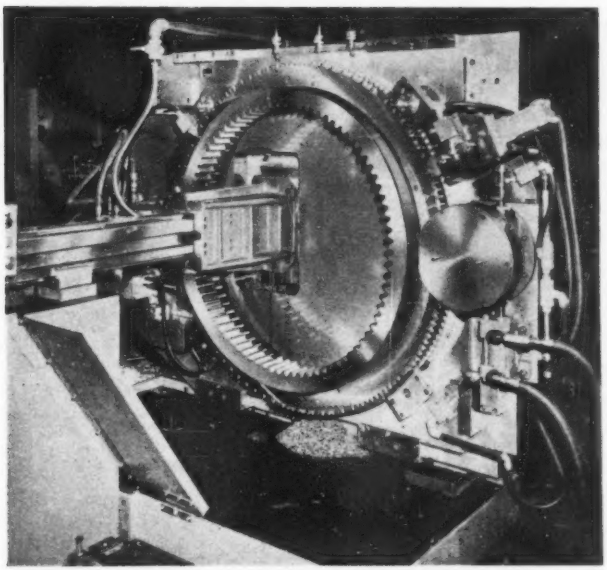
The illustration shows the machine set up to cut a Tournapull tractor steering gear, at the works of La Tourneau-Westinghouse, Peoria, Illinois. For this particular gear, the tooth-cutting time was reduced from a full day to 1½ hours. This time includes 10 min. for loading and unloading, and 10 min. for reversing the broach. On the steering gear, there are three portions to be broached: namely, a 65-tooth gear, with a pitch circle diameter of 32·5 in., a helix angle of 20 deg., and a face width of 4·5 in.; a 79-tooth helical gear, with a pitch circle diameter of 26·33 in. and a face width of 4·5 in.; and an 84-tooth straight spur gear with a pitch circle diameter of 42 in. and a face width of 4·37 in.

The faceplate, to which the work is clamped, also carries the master indexing gear, and automatic reciprocation of the broach, and indexing of the gear, are obtained hydraulically through a pawl arrangement. Teeth are broached with roughing and finishing cuts, and subsequent shaving or grinding operations are normally unnecessary for straight spur gears. A special angle-plate, bolted to the machine face, is used when semi-finishing helical gears.

Of 15 tons capacity, the machine has a 90-in. stroke, and will withstand 40 per cent overload. Hydraulic power is provided by a heavy-duty vane type pump.

The frame is of one-piece welded construction, and has heavy side-plates with rolled edges. Replaceable bronze guide shoes are provided on the cast steel ram head, and the slideways are hardened and ground, and lubricated, by gravity, from a reservoir in the head. All hydraulic and electrical controls are interlocked, and conform to J.I.C. standards.

The makers are represented in this country by Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11.



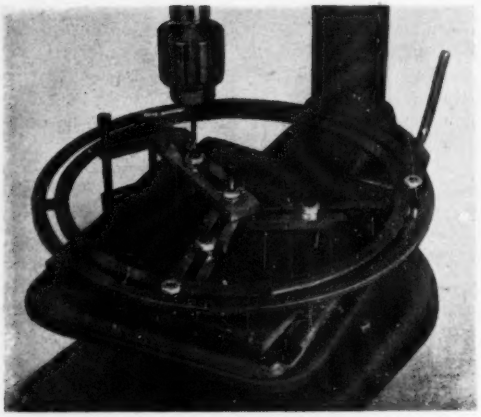
Colonial Horizontal Broaching Machine for Cutting Large Gears

Euco Holemaster Adjustable Drilling Jigs

The patent Holemaster equipment introduced by Euco Tools, Ltd., 44 London Road, Kingston-on-Thames, Surrey, enables jigs to be readily assembled by the user, for drilling ⅜-in. diameter pilot holes in work-pieces.

In the illustration is shown a jig which has been built up with this equipment for drilling three holes on the circumference of a circle. The principal components of the equipment are steel plates, which are hardened and ground. They have parallel edges, and slots extending for part of their length to take drill bushes of special design. Holes are provided near the ends of each plate which will also accommodate drill bushes. Each bush has a flange, with a ground periphery, at one end, and a screw thread at the other, and it is secured endwise in the plate by means of a nut.

With this arrangement, bushes which have been passed through the slot can be set accurately for centre distance in relation to each other, and to the bushes in the holes at the end of the plate, by means of slip gauges interposed between the flanged ends.



A Jig for Drilling Holes on a Circle, Built Up from Euco Tools Holemaster Equipment

Maximum and minimum centre distances of 4 and ½ in. are obtainable between the bushes. Alternatively, settings can be made by means of slip gauges and pins which are a close fit in the bores of the bushes. Then, the jig is secured to the workpieces by means of clamps, in preparation for drilling holes on a straight line. If required, two or more plates can be connected together endwise, to produce a jig of considerable length.

When a jig is to be assembled for drilling equally-spaced holes on the circumference of a circle, three plates are joined by a single bush, which is passed through a hole at one end of each. The outer ends are attached by means of other bushes to a ring-shaped carrier, which forms part of the equipment, and has arcuate slots to take the threaded ends of the bushes, as shown in the figure. The bushes that are passed through the slots in the plates are next set for radius with reference to the central bush, by means of slip gauges. With the aid of slip gauges or a vernier caliper, the plates are then set for angle by measurement of the chordal distances between the bushes that are to be used for actual drilling.

A hole is drilled at the centre of the circle in the work, and a pin is passed through it, and the central bush in the jig, for location purposes. The jig is next secured to the work by clamps, and the holes at the circumference of the circle are drilled. When more than three holes are required, the operation is performed in several stages. The bush plates are set at different angles for each stage, and the jig is located by pins which pass through the central bush and one of the previously drilled holes.

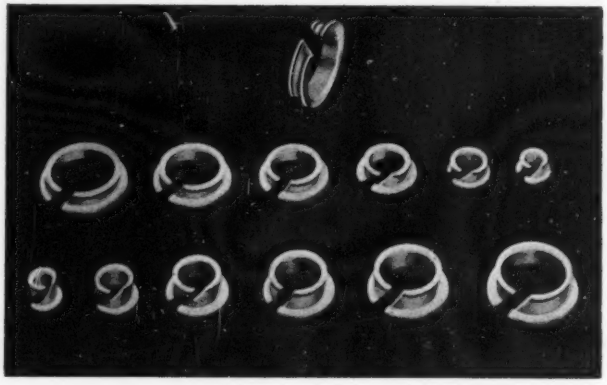
When only two holes are to be drilled in the work, at an angle in relation to a reference point, the plates are connected to each other by a bush at one end, as previously described. The outer ends of the plates are then secured to a semi-circular carrier. Since the edges of the plates are accurately parallel with each other, and with the sides of the slots, two of them can be set up in conjunction with the semi-circular carrier to form a gauge for checking conical parts for angle.

Thomson Snap-in Nylon Bearings

Examples from a range of nylon bearings introduced by Thomson Industries, Inc., Manhasset, New York, U.S.A., are shown in the figure.

Known as snap-in Nyliners, type 7, these bearings have flanges of different diameters at their ends, whereby they can be located endwise in holes in metal plates. The larger-diameter flange enables the bearing to take an end thrust load.

A helical slot, extending throughout its length, enables the bearing to be collapsed, so that the small-diameter flange may be passed through the bore in the work at assembly. The slot also allows the bearing material to expand and contract, due to variation of temperature and moisture content, without affecting the bore diameter. Bearings are available with 9 bore diameters, ranging from ¼ to ¾ in., and in two different lengths. The shorter bearings are intended for use in plates from 0·04 to 0·075 in. thick, and the longer types in plates from 0·072 to 0·135 in. thick.



Examples from the Thomson Range of Snap-in Nylon Bearings

Aircraft Manufacturing Practice—A Review of the British Industry*

By L. G. BURNARD†

It is not possible in this paper to do much more than consider the most interesting of recent developments in manufacturing practice in the British aircraft industry. In order to broaden the scope, leading airframe manufacturers were approached to contribute particulars of any developments they considered to be of interest. Their response was most helpful, and the author acknowledges his gratitude.

During the past decade, the whole aspect of manufacturing practice in the airframe industry has undergone, and is still in the process of, radical change. Many firms have adopted integration as a design philosophy, and this involves the machining of large slabs of light alloy. The workshop emphasis has accordingly changed from the fitting to the machine shop, where milling operations are now predominant.

This change has brought new problems which require the adoption of new techniques, and it is often necessary, for example, to use stretched slab to obviate distortion during machining operations. Further development will inevitably require the manipulation and machining of higher strength materials, such at titanium, and stainless and very high strength steels, also new techniques to permit the fabrication of stainless steel honeycomb structures for such vehicles as missiles and rockets.

Higher aircraft speeds demand increasing complexity of control systems, and multiplication of the parts which must be housed within the airframe. The problem is intensified with rockets and missiles, where the density of installed equipment is very high. For these reasons, it is important first to discuss developments in machining practice.

MACHINING

When designs for large integrated components were introduced about seven or eight years ago, the immediate reaction was to produce these items on existing copy-milling machines. It was soon realized that these machines had their limitations, mainly because of low cutter speeds. Attention was then turned to the possibility of using heavy-duty routers to produce the components. The early routing machines were merely adaptations of radial arm types, but special designs providing greater rigidity have since been introduced. It may be noted, moreover, that programmed numerical control is now envisaged for some of these machines, and that servo and hydraulic operation have also been applied.

One of the attractive features of the copying technique is the simplicity of the tooling. A fixture to hold the component in its correct relationship, and a series of templates to control the various machining operations, are, basically, all that is necessary.

When accurately made templates are employed on modern routing machines, the relative positions of the pockets and cut-outs, profiles, and flange thicknesses, can be controlled well within drawing limits, which are generally in the region of −0·005 in. and +0·010 in. Vertical web thicknesses can be controlled more accurately by the use of barrel stops and dial indicators.

Early routing machines had the disadvantage that it was necessary to remove the template in order to change the workpiece. Machines are built, therefore, with a structure which carries the template overhead, as shown in Fig. 1. The table of the machine, and the template holder, are jig drilled with patterns of holes in accurate relationship one to the other, so that it is possible to place a locating fixture on the bed, and a template on the support structure overhead, in the correct relative positions, without further setting.

There are three main types of these machines. With one type, the pillar carrying the swivelling arm is mounted on a slide, so that the working portion of the machine can be traversed to cover the area of the fixed bed. It is possible to build up a machine of this type to almost unlimited length.

The second type has a sliding table, and this design is particularly suitable for use where integral stiffeners must be milled into skins in the transverse direction. With a template for controlling one stiffener form mounted overhead, the tool-

* Abstract of the first part of a paper presented at the Conference on Problems of Aircraft Production organised by the Southampton Section of the Institution of Production Engineers.

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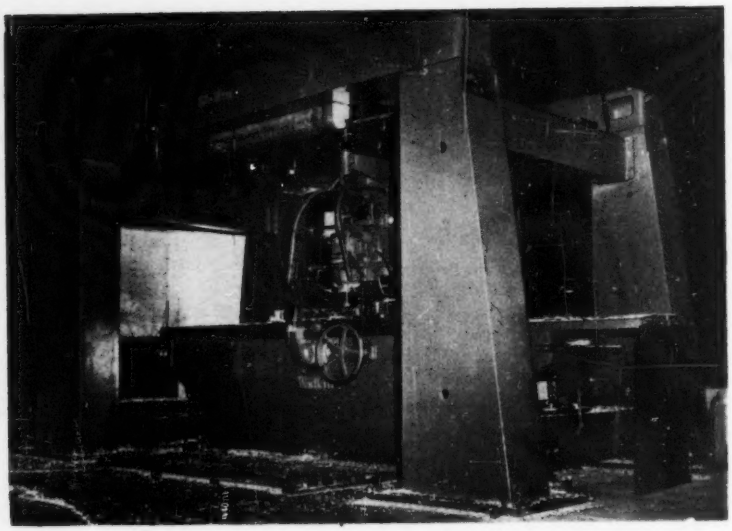

Fig. 1. A Wadkin Routing Machine with Overhead Template [Vickers-Armstrongs (Aircraft), Ltd.]

head can be traversed across the table to machine a stiffener, and returned to its starting position. The table is then indexed along to the next setting, and a second stiffener is machined. Thus, by successive movement of the table along the bed of the machine, the whole of the stiffening network can be covered. By the use of various index plates mounted on the front of the table, provision can be made for any pattern or spacing of stiffeners, with only one template.

The third type of machine, with a fixed pillar and a fixed table, is intended for normal copying work. With all these machines, heavy cuts can be taken, and the operator finds it easy to control the movement of the cutter. Due to the high rotational speeds, tooth loads are low and little manual effort is necessary. Heads of 20 h.p. are now available to enable very heavy roughing cuts to be taken, and the operator has full control of head movement, even at such powers. The cutters employed have inserted tungsten carbide blades (usually two). For wide cuts, when profiling the external peripheries of components, spiral cutters are used with inserted carbide blades. It has been found essential on all routers to use a draw bar, and mild steel cutter bodies fitting directly into the cutter spindle. Cutters held in draw-bar collets are unsatisfactory, as they tend to be pulled down into the work. Spray-mist lubrication is provided, not for cooling purposes, but in order to prevent cutter wear. With spray mist, it will be found that cutter life between re-grinds is two or three times as great as it is when the cutter is allowed to run dry.

Link-arm routers can be supplied with overhead template carriers, but are more commonly used with templates fixed directly over the workpiece, which are engaged by standard tracing rollers. With vacuum chucks set on the worktables, the sculpturing of skin panels is readily carried out. Profiling, scalloping, pocketing, and milling, and bevel-milling operations can all be performed on routers with suitable tooling. Variable bevels can be machined by providing rollers, above and below the cutting tool, which bear against templates

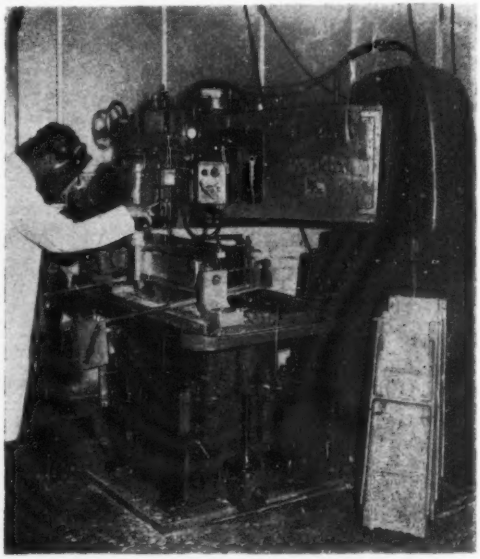

Fig. 2. Set-up for Machining a Varying Bevel Form on a Wadkin Link-arm Router. (Morfax, Ltd.)

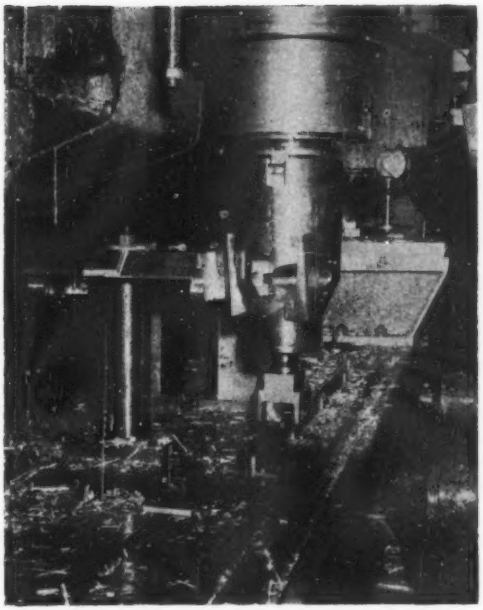

Fig. 3. A Variable-angle Cutter Set Up on a Hydrotel Machine for Producing a Varying Bevel [Vickers-Armstrongs (Aircraft), Ltd.]

mounted above and below the workpiece. The latter, together with the template system, is carried in a jig on trunnions. Owing to the different profiles of the upper and lower templates, the workpiece is caused to swivel, so that the required bevelled form is produced. The jig is carefully balanced so that the tilting force is not great. Fig. 2 shows a set-up, based on this technique, which is employed by Morfax, Ltd.

Another method of producing the bevel on a rib is illustrated in Fig. 3, which shows a set-up on a Hydrotel machine. The cutter illustrated has three inserted blades with carbide cutting edges, the angular positions of which can be varied. The blades float in radiused recesses in the cutter body. A central plunger carries a pinion, which engages with racks at the backs of the teeth, and, as the plunger is caused to move axially, the angular setting of the teeth is varied. A heavy spring, inside the body, opposes the upward movement of the central spindle. The varying angle of the bevel is controlled by a vertical face cam mounted on the fixture. For tracing the periphery of the wing form, the normal copying equipment of the machine is used and the stylus can be seen to the right of the cutter.

Fig. 4 shows a routing machine arranged for servo-operation. A 12-h.p. standard Wadkin router head is employed, which is mounted in a vertical slide. This vertical slide is supported on a carriage, which can traverse on a beam spanning the machine, to provide the transverse motion. The beam, in turn, traverses in the fore and aft direction on two ways at the extremities of the machine. The ways are faced with hardened strips, and the moving members are provided with endless chains which ensure smooth running and the minimum of friction. Two vectoring hydraulic jacks are mounted at the back of the machine, and are linked to a bracket on the traversing carriage. The admission of oil to the jacks causes the head to move in the desired direction. Valve gear for the hydraulic jacks is mounted just above their point of attachment to the head, and the oil supply passes through the hollow rams. The valves are operated by a vertical stylus rod, which is connected by a linkage to an operator's handle at the front of the machine. Movement of the

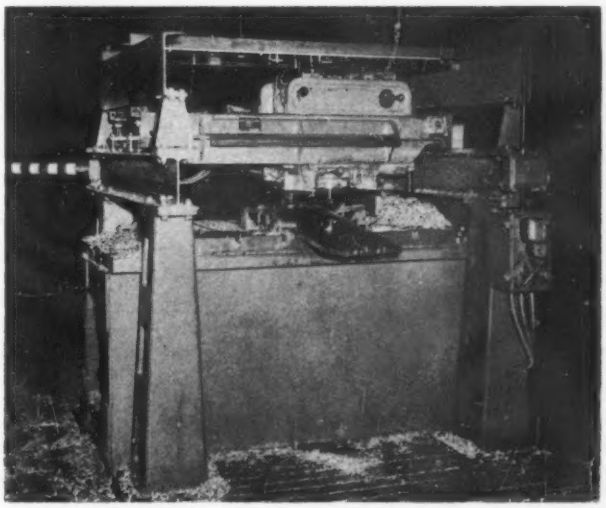

Fig. 4. A Routing Machine Arranged for Servo-operation. [Vickers-Armstrongs (Aircraft), Ltd.]

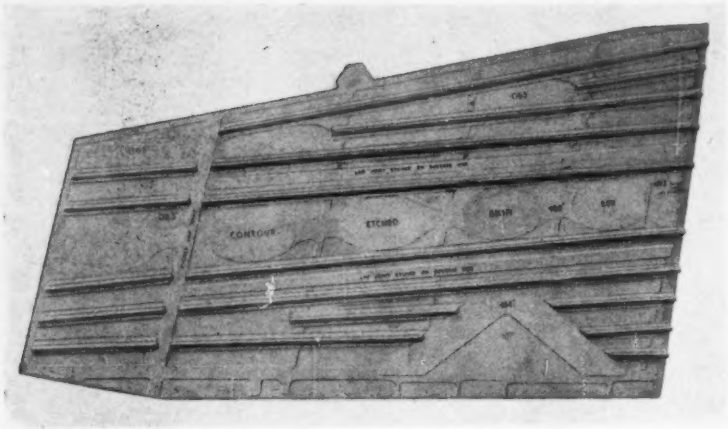

Fig. 5. A Large Wing Skin Panel Produced by Chemical Contouring. [de Havilland Aircraft Co., Ltd.]

handle results in movement of the stylus rod, and the valves are opened and closed, as required. Thus, as the handle is moved in any direction, the valves cause the jacks to move the carriage in the same direction.

Mounted above the table is a template holder. The end of the stylus carries a roller, the size of which is changed to suit the diameter of the cutter, and for roughing and finishing cuts. When the carriage is moved to engage the roller with the template, the stylus is centred and the supply of oil to the jacks is cut off, so that the carriage cannot move further in the direction of the template. The operator's linkage is connected to the stylus through a spring, and the load applied to the stylus roller does not exceed 9 oz. As on the overhead template machines already mentioned, the template holder and the work table have patterns of holes to facilitate setting the template and fixture. This machine is very fast and accurate, and no effort is required of the operator.

A further development is the adaptation of the router technique to three-dimensional copying. A separate slide, mounted on the end of a radial arm, carries a hydraulic tracer valve at the overhead template position. Another slide supports the router head, which is balanced. A linkage between the tracer valve slide and the router slide causes them to move in opposite directions, this linkage being operated by means of spring steel strip to ensure freedom from backlash. As the tracer moves over a three-dimensional pattern, mounted at the overhead template position, it controls a hydraulic servo jack, which moves the slides. The lower router slide then describes movements opposite to those of the upper tracer slide. Thus, by traversing the tracer over a pattern by hand, it is possible to produce three-dimensional forms on light alloy.

Most wing skin panels, and some fuselage skin panels, are now required to be either sculptured or integrally machined. The sculpturing of areas of wing skin can be carried out satisfactorily by chemical contouring, but some of the skin panels are too large for the existing tanks, and some of

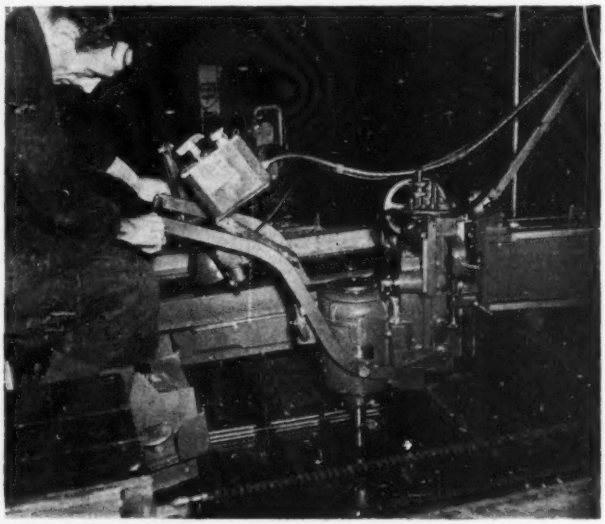

Fig. 6. A Close-up View of the Head and Operator's Station on a Skin Panel Routing Machine. [Vickers-Armstrongs (Aircraft), Ltd.]

Fig. 7. Cramic Routing Machine Built Up from Units. The Working Area is 42 ft. by 6 ft.

the forms required are rather complicated. Fig. 5 shows a large wing skin panel produced by the de Havilland Aircraft Co. by chemical etching, to provide six thickness steps from 0·280 in. to 0·063 in. Lap joints on the reverse side are also etched. Routers have been adapted for this type of machine sculpturing, and Fig. 6 shows a close-up view of a head on such a machine.

With this particular design, two radial-arm routers span the width of a 6-ft. sheet, being mounted on opposite sides of, and staggered along, the bed. Beneath the working area of each head there is a table carrying a vacuum chuck. The remainder of the bed consists of a roller conveyor, so that the sheets can readily be moved into position in the working area.

The operator sits on a carriage, which is traversed on a bridge over the top of the machine. He is able to control his movements, over the work table, by means of a foot-operated electrical drive. Templates, corresponding to the cut-outs and the sculptured pockets, are bolted directly to the sheet, so that they move with it as it is traversed along the machine. An area of about 9 sq. ft. is covered by the sweep of a radial arm router head, and, as each area is completed, the workpiece is indexed to a fresh position on the vacuum table, and clamped. In this manner, the whole wing skin panel is machined in stages.

The Fairey Aviation Co., Ltd., have done a considerable amount of work on the development of profile routing. They have, for instance, designed and built a machine, known as the Green Linnet, equipped with high-speed routing heads of their own design, which run at 3,000/6,000 r.p.m. and are rated at 10/20 h.p. Three types of heads have been designed and produced, the latest of which incorporates hydraulic dynamic bearings.

More recently, in conjunction with Ferranti, Ltd., and the Production Development Department of the Ministry of Supply, a large 3-dimensional, programme-controlled, milling machine has been built, which is now under test at the Fairey works. It is stated that this machine will be capable of removing up to 50 lb. of aluminium per min., under completely automatic control.

Machines for routing operations have been designed by the Cramic Engineering Co., Ltd. An important feature of these machines is the use of the Dexter linear ball bearing. This bearing consists of sections of hardened and ground rod, located in a machined horizontal way. On the traversing member, there is a similar set of rods, and between them run standard bearing balls. Side play can be taken up by adjustment to the bearing on the moving member. The balls are continuously circulated, and the movement is very smooth and almost free from friction. The bearing does not become clogged, or loaded with chips or other foreign matter, which fall clear through the race assembly. Movements are obtained by two hand-wheels at the operator's position, through drums and cables. A template can readily be followed, and "feel" is quite sensitive.

The Cramic machine is very suitable for unit construction, as will be evident from Fig. 7. The working area of this machine is 42 ft. by 6 ft., and it is built up from a series of units. There are three routing heads, and they can be operated simultaneously. Any length of Dexter bearing can be built up, as desired, its accuracy depending only on the accuracy of the square ways in which

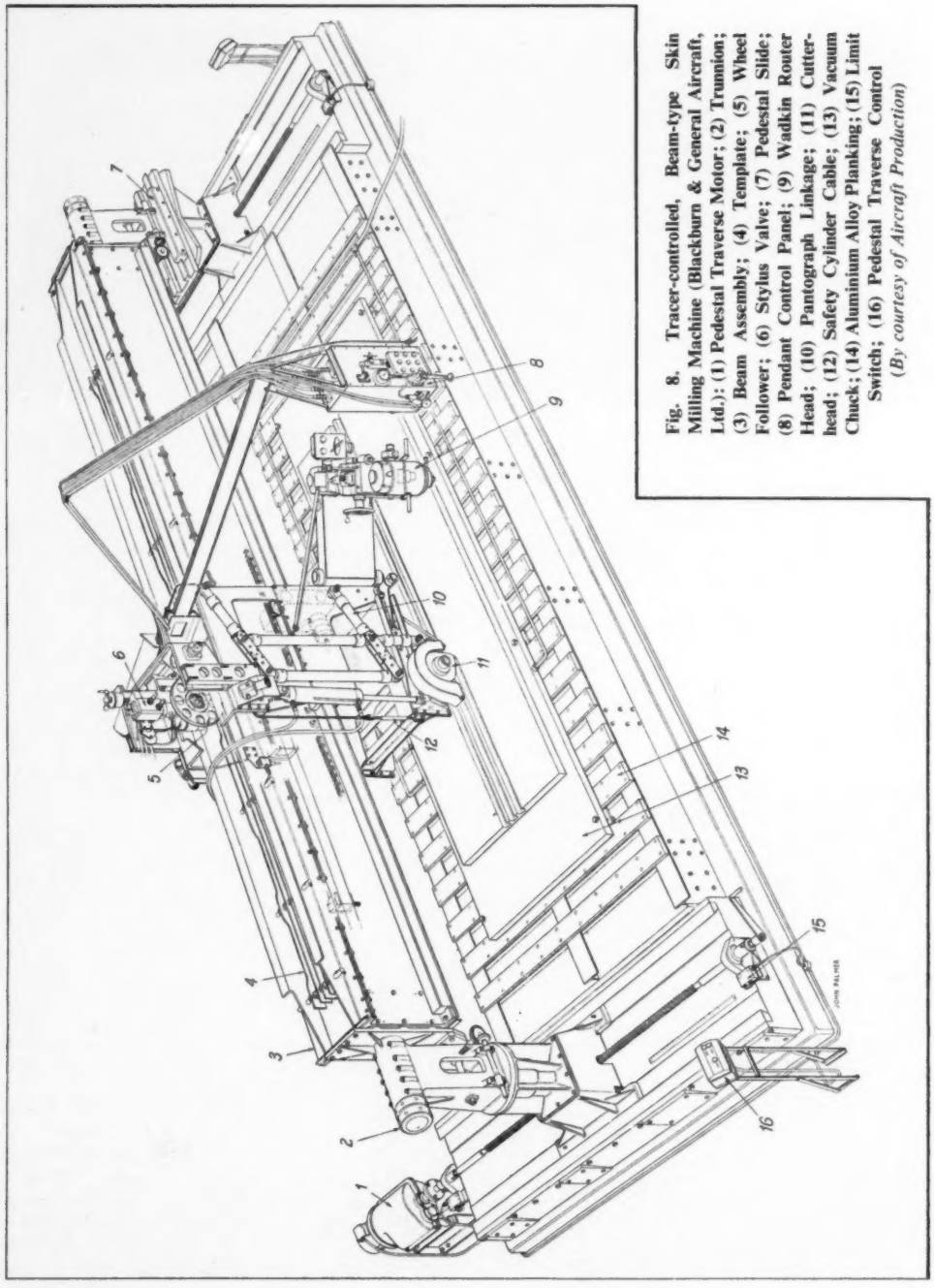

Fig. 8. Tracer-controlled, Beam-type Skin Milling Machine (Blackburn & General Aircraft, Ltd.): (1) Pedestal Traverse Motor; (2) Trunnion; (3) Beam Assembly; (4) Template; (5) Wheel Follower; (6) Stylus Valve; (7) Pedestal Slide; (8) Pendant Control Panel; (9) Wadkin Router Head; (10) Pantograph Linkage; (11) Cutter-head; (12) Safety Cylinder Cable; (13) Vacuum Chuck; (14) Aluminium Alloy Planking; (15) Limit Switch; (16) Pedestal Traverse Control
(By courtesy of Aircraft Production)

the ground rods are inserted. There are many variants of this type of machine, depending upon the nature of the work to be performed.

Several firms are investigating the possibilities of routing high-tensile steels. Router heads of 10 h.p. have been produced, with a speed of 6,000 r.p.m. By using tungsten cutters and CO_2 cooling, it is possible to machine high-tensile steels at these speeds. Cutter life is very short, however, especially for pocketing operations where the pressure on the face of the cutter is high. In the experiments of which the author has information, only about 12-14 cu. in. of material has been removed before the cutter needed re-grinding. The problem is still being tackled, but the considerable cutter wear remains the principal difficulty.

Ceramic cutters have also been tried, but have broken down almost immediately. Whether failure is due to mechanical, or thermal, shock is not yet known.

MILLING WING SKINS

Many current British aircraft designs incorporate integrally-stiffened wing skin panels. Generally, these panels are comparatively narrow, partly because of the early inability to obtain stretch-levelled slab with a cross-sectional area greater than 40 to 44 sq. in. Stretch-levelled slab of approximately 200 sq. in. cross-sectional area can now be supplied, but the wing panels still remain comparatively narrow, owing to the application of the "fail safe" design philosophy. Some of these panels are machined on Onsrud spar millers, and others on specially-designed equipment.

A tracer-controlled, beam-type, skin miller, made by Blackburn & General Aircraft, Ltd., is illustrated in Fig. 8. A fabricated beam, 26 ft. long, is supported at each end by a travelling vertical member. These members can be traversed on slideways at the ends of the machine bed, and, since they can be adjusted separately, converging stiffeners and angular stiffeners can be machined on the panels. The beam carries a 50-h.p. Onsrud cutter head, which is controlled in the vertical direction by means of a hydraulic copying device.

Mounted centrally along the top of the beam are template holders, and a pack of templates can be inserted, so that various programmes can be completed at one setting. A tracer valve and stylus roller are mounted on a slide assembly bolted to the top of the cutting head carriage. The Onsrud motor is carried between link arms, which are controlled vertically by means of two hydraulic jacks. As the arms describe a radius, a pantograph system ensures that the stylus roller and the centre of the work spindle are always in vertical alignment, so that it is unnecessary to develop special templates. With this arrangement, the cutter head can be caused to rise and fall for machining tapered stiffeners and skins, and to leave thicker rib platforms where required. Two-bladed cutters up to 17 in. diameter and 4 in. face width, with inserted tungsten carbide tips, are employed. The surface speed is about 10,000 ft. per min., and, at 22½ h.p., 105 cu. in. per min. are removed. A link-arm router head is also fitted to the machine, to enable cut-outs to be made where necessary.

A Jameson machine has been developed for the accurate production of large wing panels which obey the laws of straight line generation. It will produce the orthodox type of aerofoil for which the generation lines meet at a focal point, also forms incorporating offset taper and twist. In addition, delta forms can be obtained.

The purpose of this machine is to produce thin aerofoil membranes with the minimum of distortion due to thermal stresses set up during machining. It has a good metal removal capacity during the roughing stages.

Single-point cutting takes place in both directions, and a high cutting speed can be employed, because the reciprocating member is comparatively light and the drive is provided by a screw and an epicyclic gearbox, each of which has a low moment of inertia. The cutter-box reciprocates in a cutter-box slide, which is retracted hydraulically at the ends of the stroke. The cutter-box slide is mounted in a swivelling member attached to a slide on the centre column. The two end columns provide additional support, and the slide assembly is locked to them hydraulically during the cut.

In the existing machine, one end column is equipped with a screw which is connected by a shaft to the main raising screw in the centre column. By altering the ratio between the screws, taper can be obtained. To avoid high frictional resistance between the raising screw and nut, hydraulic thrusters are provided to support the weight of the assembly. The component is mounted either on compensating jacks, or a vacuum chuck, attached to the work table, which can be turned to the horizontal position by a power drive through pinions and sectors. A template is attached to the table at each end. These templates correspond, in profile, to datum contours of the aerofoil at about 25-ft. centres. Cut is applied by retracting the contour plates through suitable mechanisms, which are interconnected by a shaft which spans the length of the table. Each end of the cutter-box slide is equipped with a contact member of the same radius as the cutting tool. Fig. 9 shows the machine during construction.

Fig. 9. A View Showing the J. L. Jameson Aerofoil Generating Machine in Course of Construction

MACHINING HIGH TENSILE STEELS

Many airframe components are now made from steels with tensile strengths of the order of 80-100 tons. These steels present difficult problems as regards the supply of cutters, cutter life, and operation times. Where face milling is involved, the problem is not so critical because negative rake, inserted-tooth face cutters can be used, and high cutting rates are possible. Very few faces on aircraft components can, however, be machined in this simple manner, and we are mainly concerned with profiling and pocketing, for which long, slender cutters must often be employed. As a rule, these components are machined on hydraulic copy mills such as the Hydrotel and the Rigid. Because of the necessarily low cutting speeds and tooth loads, the full h.p. of such machines cannot be utilized. The fact that cutter diameters are small also tends to reduce the possible horse-power input.

Because it has been found that carbides break down very rapidly under the elastic drive conditions which prevail in hydraulic copy-milling machines, we are, for the most part, using high-speed cutters. There are, of course, some instances where cemented carbides are being employed. With high-speed steel cutters, the maximum surface speed is about 50 ft. per min. and tooth loads vary from 0·022 in. to 0·008 in., depending on the slenderness of the cutter. In general the metal is "attacked" as much as the cutter will permit. With slender end mills, however, this is not always possible, and the cutter "picks" at the work.

In order to speed up production, a variety of twin heads has been designed and made, so that two components can be machined at once. Fortunately, most aircraft components are long in one direction and narrow in the other, so that the problem of accommodating them is comparatively simple. Such twin heads are available for both Rigid and Hydrotel machines.

A cutter which has been developed recently is the Strasmann type. This cutter has a helical thread form machined on it, and is made from a high-speed cobalt steel. The peculiar form of the cutter has the effect of lengthening the cutting edges, breaking up the chips and reducing the tooth loads. Very heavy cuts can be taken with impunity. The accompanying table shows how the surface speed and feed can be increased, also the greater tool life obtained as compared with

COMPARISONS OF PERFORMANCE OF MILLING CUTTERS ON S.99 AIRCRAFT STEEL

—	Plain slab mill	Strasmann slab mill	Plain end mill	Strasmann end mill	Inserted tooth fly mill
Number of teeth	12	18	6	6	12
R.p.m.	24	24	94	94	40
Diameter, in.	5·5	6	1·5	1·5	5
Feed, in. per min.	0·5	0·5	2	2	1
Depth of cut, in.	0·1	0·5	0·05	0·1	0·25
Width of cut, in.	6	12	2	2	5
Life of tool, passes	½	1	1	4	—
Volume removed per min., cu. in.	0·3	3·0	0·2	0·4	1·25
Volume removed per re-grind, cu. in.	34	684	4	32	60
Volume removed per tooth, cu. in.	0·001	0·007	0·00035	0·0007	0·0025
Feed per tooth, in. (max.)	0·0017	0·0112	0·0035	0·0035	0·002

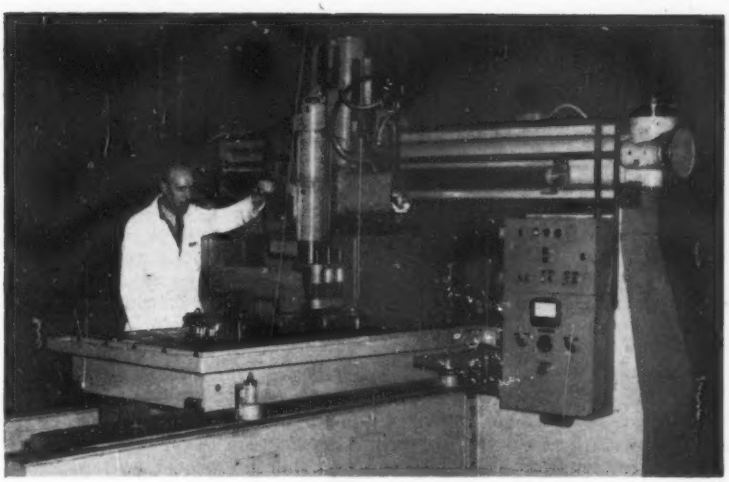

Fig. 10. Numerically-controlled Co-ordinate Positioning Drilling Machine [Vickers Armstrongs (Aircraft), Ltd.]

ordinary high-speed milling cutters. Volume of metal removed is very much greater, and these cutters have proved to be highly efficient.

Most firms have been carrying out experiments with ceramic cutting tools. They proved to be reasonably efficient for the single-point turning of nimonic alloys. In the author's experience, they are not yet as satisfactory as cemented carbides for other materials. No success has been achieved with ceramic-tipped milling cutters. Ceramic tips do not take kindly to shock loads, and thermal shock will also break them down very quickly.

Spiral carbide cutters have been introduced by Production Tool Alloy, Ltd., Sharpenhoe, Beds., and are available to industry. Aircraft Production Development initiated their manufacture and Short Bros. & Harland carried out production testing and development work. They have been used, for example, for machining flap tracks. The finish obtained is very good, and there seems to be a future for this type of cutter when it has been further developed.

Short Bros. & Harland have also adapted the gun reamer for the production of reamed holes with a very high finish, in high tensile steels. This gun reaming technique has been described elsewhere, and its great advantage is that high speeds are possible, with finishes of the order of 6 micro inches. The reamer acts as a single-point tool, cutting its own path through the material. It will not "run" and follow the path of the previously drilled under-size hole.

PROGRAMMED CONTROL OF MACHINE TOOLS

Many aircraft firms are considering numerical control for machine tools. Some have machines fitted with this type of control, which are already working, and some are producing machines for their own use, together with the associated controls. There is a number of systems available, including those developed by Ferranti, Ltd., E.M.I. Electronics, Ltd., Ekco Electronics, Ltd., and British Thomson-Houston Co., Ltd. These systems have been applied to standard milling machines, but, in the future, we must consider the design of the basic machine tools in conjunction with the electronics.

Fig. 10 shows a co-ordinate drilling machine operated by means of punched paper tape. On this machine, a count is taken directly from the lead screw, which is of the re-circulating ball-nut type, made to limits of $\pm 0{\cdot}0003$ in. per foot, with an overall accuracy of 0·002 in. Jig boring accuracy is not essential for the purpose for which the machine is intended, namely, the drilling of large aircraft fittings without jigs. It is considered that if an overall accuracy of 0·001 in. between holes in a group is attained this will suffice for normal aircraft requirements. Similarly, a spacing accuracy of 0·003 in., as between one group of holes and another, is regarded as satisfactory. The machine has been specially designed to match the electronic control gear, and the table is mounted on roller slideways to reduce inertia and friction. Both the machine and the electronic control system were designed by Vickers-Armstrongs (Aircraft), Ltd.

Mounted on the end of each lead screw, there is a geared slotted disc. This disc interrupts rays from a light source, and two photo-electric cells, mounted behind the disc, count the resulting pulses. The arrangement gives one pulse for every 0·001 in. of movement of the slideway. Punched paper tape, coded with the co-ordinate positions,

is fed through a normal teleprinter reading head, connections from which are made to banks of uni-selector switches. The switches move to a position which is an analogue of the ordinate number punched into the paper tape. Each switch position is connected to the corresponding cathode position of a bank of decatron valves, arranged in cascade, so that the number introduced into the uni-selector is transferred to the decatron counter. When the table moves, the pulses from the interrupted light source are counted by the decatron valves, and after a movement of the requisite number of thousandths of an inch has been completed, the count on the decatron valves is reduced to zero, and the motion stops.

The arrangement is such that the table speed is progressively reduced as the unit thousandths are approached, and the final position is reached slowly in order to eliminate inertial over-run. For monitoring purposes, a second tape is punched with the complement of the original ordinate. This second tape controls another bank of decatron valves, so that while one series counts to zero, the other counts to 99·999. It is unlikely that a pulse will be missed in both counting units at the same time. If the two counts do not add up to 99·999, the machine signals an error, and the drilling head will not operate. Inching buttons are provided so that the operator can correct the miscount, and the machine will then operate.

There are several other co-ordinate positioning machines, including one made by Industrial Technics, Ltd., of Southampton, which is equipped with E.M.I. co-ordinate positioning controls. The slides incorporate linear-type, re-circulating ball bushes, which run on hardened and ground bars suitably mounted on the bed.

The British Thomson-Houston Co. produce an extremely accurate co-ordinate positioning system, which is being fitted to jig borers. This system gives repeatability of position to 0·0001 in., and the information is fed into the console by means of punched cards.

A very neat and simple automatic co-ordinate setting control is made by Ekco Electronics, Ltd. It can be employed with almost any two-dimensional system, such as that of a milling machine. Its compactness will be evident from Fig. 11. The control is fitted directly to the lead-screw of the machine, and positioning accuracy depends, of course, upon the accuracy of the screw. It should be pointed out, however, that if the inaccuracies are known and plotted, they can be allowed for in setting up the ordinates. The control will set any lead-screw to within 1/500th of a turn, and for a 10-t.p.i. screw, this represents 0·0002 in. of linear movement of the work table. For a 4-t.p.i. lead-screw, the accuracy of setting would be of the order of 0·0005 in. For this analogue system, a series of Wheatstone bridges is employed, the master potentiometers of which are set to the desired measurements. The ordinates are "rung" in by hand, on a control box, to four decimal places. A ¾-h.p. motor is employed for driving the lead-screw. Development work is being carried out in connection with a punched card information storage system.

A very simple co-ordinate positioning device is being developed by Vickers-Armstrongs (Aircraft), Ltd., which comprises, basically, a series of commutators geared to the lead screw of a co-ordinate table. If there are 10 segments on each commutator, and these are geared in a decade arrangement, so that the ultimate commutator is capable of discriminating 0·001 in. travel of the table from one segment to another, then, at any position of the table, the segments of the commutators will form a unique electrical pattern. The console control comprises simple rotary switches arranged in decade form, whereby a series of magnetic relays is set to provide an analogue of the desired path through the commutator system. Electrical controls then bring the two systems into balance. It will be apparent that, with the minimum of relays and commutator positions, the table may be set to increments of 0·001 in. Like the Ekco control, this system, which is under development at the moment, requires no valves.

There is a number of continuous two-dimensional numerical control systems. A control made by E.M.I. Electronics, Ltd., is based on an analogue system, and can be fitted to various standard machine tools, including Cincinnati and other types of vertical milling machines. This control can also be fitted to hydraulic copying machines where

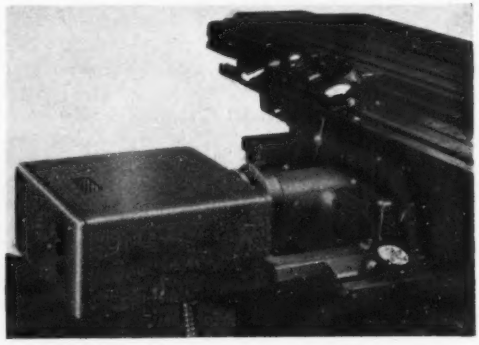

Fig. 11. Ekco Co-ordinate Positioning Control Box as Fitted to One Leadscrew (Ekco Electronics, Ltd.)

the table is operated by hydraulic motors or rams. Hydraulic operation permits a greater rate of acceleration than is possible with electric motor drive, so that the speed of profiling is greater.

Ferranti, Ltd., market a digital data system for automatic continuous 3-dimensional control of machine tools. The positions of the machine tool elements are monitored to an accuracy of 0·0002 in. by means of signals from a diffraction grating system. Electronic control is effected by means of pulses on a magnetic tape, which can be balanced against the feed-back from the machine tool table, through an electronic system driving a servo motor.

On a civil aircraft, there are numerous stringers of uniform section, linking together the frame structure and the skin. These stringers are generally very long, and require to be pierced, or pre-drilled, at the points of connection with the frame and other members. Grouping of holes varies from stringer to stringer, and, hitherto, it has been necessary to employ machines equipped with metal templates which control the hole positions.

Vickers-Armstrongs (Aircraft), Ltd., have designed a machine which automatically pierces any type of top-hat section stringer with any required hole pattern. Fortunately, on the aircraft in question, the stringers are all of the same section, so that it is unnecessary to change the dies. The hole requirements, however, vary considerably. When changing from one piercing programme to another, it is only necessary to provide a punched paper tape.

This tape is fed into a reading head, and the stringer is advanced, under electronic control, through the piercing head, where four pneumatically-operated punches pierce the holes in the correct positions. Movement is imparted to the stringer by means of a rack and pinion drive, and the count is taken directly from this drive. The electronic system is basically the same as that described in connection with the co-ordinate drilling machine, an interrupted light source being employed, with a decatron valve circuit for counting. The pneumatic circuit is controlled by means of electro-pneumatic solenoid devices, from instructions on the tape. As each punching position is reached, the stringer is held stationary by means of an electric brake. The appropriate pneumatic circuit operates the punch to pierce the hole or holes, and the stringer is again advanced. Information must therefore be punched into the tape for controlling the pneumatic circuits, in addition to the positioning of the stringer.

A lofting machine has been made for Vickers-Armstrongs (Aircraft), Ltd., which incorporates electronic positioning control. Ordinates can be "rung" in by means of rotary switches, and the machine members will move to the required position and mark the template material for the loft lines. It is not considered necessary, at present, to go to the trouble of punching tapes for one-off operations such as lofting, and the information is therefore introduced by means of a manual switch board. In addition to laying out the template material, the machine will rule any desired grid system on the template, and will interpolate any curve. An optical system is provided for interpolation. With this system, a pair of crossed lines is registered with the curve, and the ordinates are read-off on a bank of decatron valves. Any empirically obtained curve can thus be measured and recorded accurately.

Ferranti, Ltd., have produced a similar type of machine, which is based on their well-known two-dimensional continuous positioning control, and draws out the actual profile of the component on stable material. Other manufacturers are designing and offering similar machines.

Much work is in progress in the United Kingdom at the present time on the development of numerical control. For the aircraft industry, such control offers a means whereby lead time for aircraft can be considerably reduced. Numerically-controlled machines need very little tooling. A fixture which will hold the part in the correct position with relation to a fixed datum, and a punched paper tape or magnetic tape, are all that is required. Modifications are easily incorporated. For example, for drilling, the basic holding fixture need not be altered, and provision can readily be made for any new holes, or hole positions, by changing the information on the tape.

An abstract of the second part of Mr. Burnard's paper will be published in a forthcoming issue of MACHINERY.

PACKAGED ELECTRONICS FOR LOCKHEED FIGHTER. The Lockheed Aircraft Corporation, U.S.A., has developed an integrated electronics system for use on the F.104 Starfighter. With this system, the equipment is packaged into a series of units, which can readily be changed to convert the machine for different types of work. Each unit is housed in a container which resembles a military petrol can.

It is stated that the new system has resulted in savings of about 20 per cent in weight, and 50 per cent in space, as compared with those normally required for electronic equipment. Each unit can be connected readily, by means of plugs, and removal for servicing and maintenance is thus simplified. Some of the units are installed behind the pilot's cockpit, where they are slid into position on vertical racks, and all are served by a comprehensive forced air cooling system.

Cincinnati Milling Machines Expansion

Expansion programmes carried out during the past ten years by Cincinnati Milling Machines, Ltd., Birmingham, have considerably extended the factory floor space, and, with the recent addition of the administration block shown in Fig. 1, the works are now among the most up to date of their kind in the country. The extensions, together with the installation of new equipment, have enabled the factory to be completely re-organized on a flow-production basis, with the result that a noteworthy degree of efficiency has been achieved.

The first British-built Cincinnati milling machines and cutter grinding machines, it may be recalled, were produced in 1934, and since then the company has made steady progress. In 1946, Hordern, Mason & Edwards, Ltd., with over 50 years' experience in the design and use of power presses, became associated with the Cincinnati group.

In 1950, the company acquired E. W. Wynn (Ironfounders), Ltd., Cannock, thereby ensuring a supply of high-grade machine-tool castings. The Heald Company, in the U.S.A., internationally known as makers of internal grinders and Bore-matic machines, joined the Cincinnati group in 1955, and a range of Heald machines is now being built in the re-organized Birmingham works.

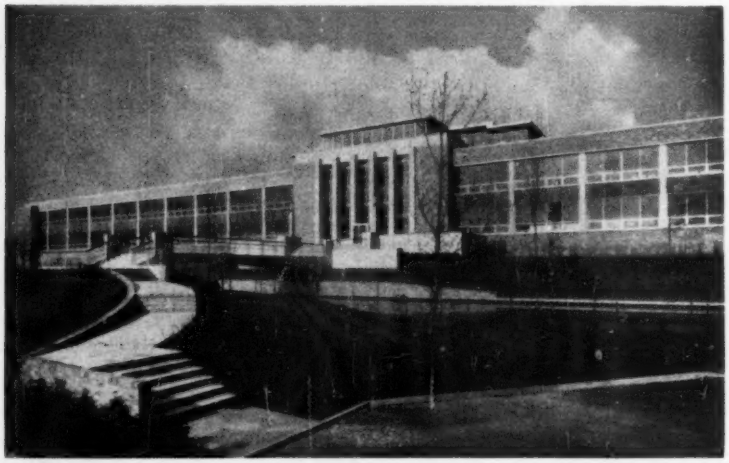

Fig. 1. A View of the New Administration Building of Cincinnati Milling Machines, Ltd., Birmingham

THE ADMINISTRATION BUILDING

The new administration building extends for 570 ft. behind the Fazeley and Birmingham canal, over which a bridge has been built to provide access from Kingsbury Road. What was originally the rear wall of the main works has been reconstructed to conform with the architecture of the new building, and the total frontage is now 942 ft.

In planning the new building, which houses the various administrative departments, production and design offices, conference and reception rooms, an auditorium, and the works and staff canteens, decisions regarding the choice of materials were based on length of life, and ability to retain a new appearance over a period of years. For example, an attractive tiled finish is extensively employed for walls and floors, and a very high standard of design and workmanship has been maintained throughout. The additional expense involved, it is considered, will be repaid amply by the important reductions in cleaning and maintenance costs that will result from this policy. All service pipes and cables are contained in ducts beneath the floors, or within the walls, and telephones and dictating machines are wired from individual points beneath the desks. Diffused lighting, and ceilings designed for sound-damping, ensure very good working conditions.

The auditorium, with a seating capacity for 280 people, is fully equipped for the presentation of films and stage performances, and is provided with its own air conditioning plant. Works and staff canteens, which are modern in all respects, are served by electric lifts from tiled kitchens below. The tables in the works canteen are of special design, with attached stools, which can be swivelled underneath the table tops when not in

Fig. 2. One of the Assembly Lines for Cincinnati Knee-type Machines

use, to permit free movement of mechanical floor-cleaning equipment.

In addition, the new administration building houses the experimental shop. This department, which is adjacent to the main machine shop, is equipped with various types of Cincinnati machine tools, and development work on cutting techniques is carried out to establish the most economical methods of producing particular components. A bus-bar electrical point system is provided in the basement beneath the floor of the department, which enables a machine readily to be wired up, without the need for trailing cables, irrespective of its position.

Reference may also be made to a new works service block, which has been built at the Woodlands Farm factory entrance. Here, are heated and ventilated lockers, and wash-basins and showers for works employees, also a surgery, rest rooms, apprentice class-rooms, and the employment office.

CINCINNATI FACTORY LAYOUT

The main factory area is laid out for the construction of general-purpose, die-sinking, and production milling machines, with table travels from 18 in. up to 14 ft., and spindle driving motors from 1 up to 50 h.p. In addition, the range includes vertical surface broaching machines, centreless grinders, cutter grinders, special milling machines and horizontal broaching machines, and Heald internal grinders and Borematics.

In general, the heavy machine tools used in production, also the assembly lines for the larger machines, are arranged towards the outer walls of the building, with light machining, sub-assembly sections, and assembly of the smaller machine tools, in the centre. Flow-line techniques are employed for machine assembly wherever possible. For general-purpose knee- and column-type milling machines, the complete process, from the start of assembly to dispatch, is carried out in a straight line, irrespective of the machine size and type (plain, universal or vertical). Four parallel lines are employed, simultaneously, upon the production

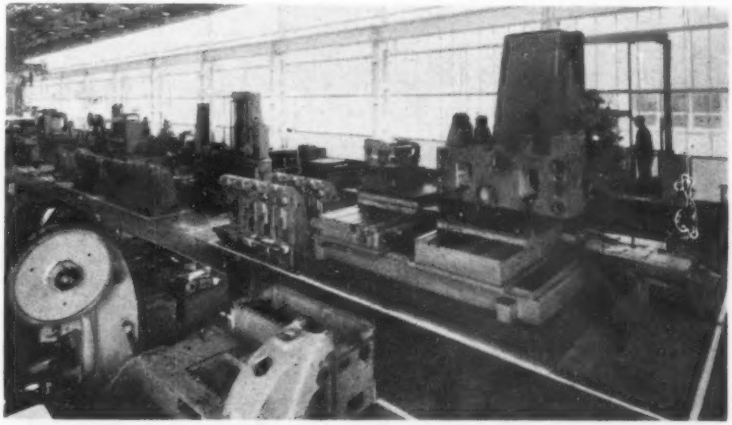

Fig. 3. Cincinnati Travelling-column Hydrotel Milling Machine Installed in the H.M.E. Works for Machining Press Frames. Duplex Tables Enable Workpieces to be Loaded and Unloaded while Machining Operations are in Progress. Each Table can Support a Load of 25 tons

of two forms of knee and column milling machines, one knee-type production machine, and one type of cutter grinder. Extending parallel with these lines, are assembly lines for a small knee and column die-sinking machine, centreless grinding machines, and the range of British-built Heald internal grinders and Borematics.

The various sub-assemblies (for example, knees, saddle and table units, and speed change and feed boxes) are built-up, and independently run and tested before being permanently fitted to the machines. In addition, each completed machine is run and thoroughly tested before it is finally inspected. Fully-assembled and tested machines then pass to a paint shop located at the end of the lines, and, after the finishing operations have been carried out, parts such as instruction plates, dials, and handwheels are fitted. A view of one of the assembly lines, showing a batch of machines on their wheeled trolleys, is given in Fig. 2.

The unit construction, fixed-bed type, Hypowermatic production milling machines, and bed-type die-sinking machines, are built up by a combination of flow-line and batch systems of assembly. Sub-assemblies, such as hydraulic units, feed mechanisms, and spindle carriers, are completed at separate stations, and are run and tested independently before assembly to the machines. This technique is also applied to machines with special features, and, wherever special tooling is fitted, the final testing of the machine and equipment is carried out away from the assembly sections, so that the normal production flow of standard machines is not interrupted.

Prior to re-organization, the main entrance to the Cincinnati works was from Woodlands Farm Road. The original office block, there situated, has now been arranged to accommodate the main spares stores, on three floors. With the exception of the larger castings, all parts for the various assemblies and sub-assemblies authorized for a particular batch of machines are distributed from this main stores to the individual assembly section stores.

Attention may also be drawn to an important part of the firm's manufacturing facilities which is devoted to the production of arbors, adapters, collet chucks, quick-change spindle equipment, and other accessories. Extensive use is made of jigs and fixtures throughout all machining sections of the factory, to ensure accuracy and interchangeability of all the machine components. A well-equipped toolroom, located in a central area of the shop floor, is provided for production of the latter, also for the construction of special machine tool equipment to meet customers' requirements.

HORDERN, MASON & EDWARDS, LTD.

Output of H.M.E. power presses has increased very considerably since 1946, when the company became part of the Cincinnati group, and this rapid growth is attributed to the introduction of new and improved types, and to the adoption of up-to-date production methods. The most recent extension to this section of the plant, completed in 1957, is a high-lift bay, covering 25,500 sq. ft., in which the heavy-machining operations are performed, and the presses are assembled and tested.

Fig. 4. The Demonstration Bay for H.M.E. Presses

The machine tools installed include a Cincinnati travelling column, Hydrotel milling machine, seen on the right in Fig. 3, with a 10-ft. wide by 18-ft. long main table, on which are mounted two heavy-duty, power-operated indexing tables, each capable of carrying a load of 25 tons. The horizontal travel of the column is 18 ft., and the vertical travel of the spindle head, 7 ft., and optical setting facilities are provided for both motions. Drive to the cutter spindle is provided by a 30-h.p. motor. This machine is

used principally for handling press frames, milling operations being performed on one large workpiece, or, more frequently, on a group of smaller press frames, while workpieces are being unloaded and loaded on the other indexing table. In this way, virtually continuous operation is ensured. Reference may also be made to a Cincinnati 36- by 120-in. horizontal Hydrotel, fitted with a large indexing table, which is employed for milling the side bosses on all open-front press frames. Other machines available include a large horizontal borer, with provision for optical setting.

A view of the press demonstration bay in the H.M.E. works is given in Fig. 4. Features of the company's OP range of open-front presses, which are now well known, include absence of tie bars, an angular arrangement of the crankshaft bearings, a simple design of stroke-changing mechanism, a sliding-block clutch which is readily adjustable for single-stroke or continuous running, and a one-shot lubrication system.

The most recent development is the 100-ton Rigispeed double-sided press, which is designed for the high-speed production of precision parts from strip or coil material. A hydraulic variable-speed drives provides operating speeds from zero up to 250 strokes per min., and it may be noted that the press can be inched accurately, in the forward and reverse directions, in order to facilitate tool setting. The press is controlled by an electro-pneumatic friction clutch, which enables the slide to be stopped at any position in the stroke. Pneumatic counter-balancing is provided for the slide, and there is a lubrication system of the cascade circulating type.

Reference may also be made to the new twin-drive, geared, double-crank press, which is being built, at present, in a 300-ton size. A feature of this press is that expansion of the frame tie rods, preparatory to shrinking, is effected by means of the firm's special arrangement of electric heating elements, which are actually incorporated in the rods.

By merely switching on the current, the bars can be uniformly expanded in about 20 min. One advantage of this feature is that it enables the slide to be readily released in the event of a jam occurring at bottom centre. Attention may also be drawn to the power-operated adjustment, for the pneumatically-balanced slide, with very sensitive push button control, and the motor-driven oil pump for lubrication of the press. The various types of H.M.E. drawing presses may also be seen in the demonstration bay.

Trade Publications

THE CARBORUNDUM CO., LTD., Trafford Park, Manchester, 17. Service Bulletin No. 1 is devoted to the company's diamond products which include wheels of a wide variety of forms. Bulletin No. 2 is concerned with diamond products for off-hand grinding cemented carbides, and Bulletin No. 4 gives mounting and operating instructions.

C. C. WAKEFIELD & CO., LTD., 46 Grosvenor Street, London, W.1. Booklet describing the operation of the new types PF and PFL oil and grease distributors. These units are designed to receive a continuous supply of lubricant by way of a single inlet, and to deliver it to a number of additional points in equal quantities. They may be fed by mechanical lubricator or grease gun.

A. COOKSLEY & CO., LTD., 21-25 Tabernacle Street, London, E.C.2. Abridged catalogue covering an extensive range of woodworking machinery which includes a universal crosscut saw, various types of saw benches, bandsaws, spindle moulders, surface planers, thicknessers, universal woodworkers, mortisers, belt sanders, and a wood-turning lathe. Numerous tools and accessories are also listed.

AIR CONTROL INSTALLATIONS, LTD., Ruislip, Middlesex. Recent publications issued by the company include a brochure entitled "better air" in which their range of products is illustrated. Others are concerned with fans; the Dusman collector; the Roll-O-Matic automatic, renewable media, air filter; small blowers, cooling fans and dust filters; the Amerclone dry centrifugal dust collector; the Amerjet reverse jet type fabric dust collector; the Electro-Mist precipitator for oil mist and fume collection; the Cycoil type P low resistance oil bath air cleaner; Bifurcator fans; design of Roto-Clone dust control systems and calculation of pressure losses; and foundry dust control data.

BROCKHOUSE ADVERTISING DIVISION, 25 Hanover Square, London, W.1. Publication entitled "Notebook on Brockhouse" in which reference is made to the various divisions, branches and subsidiary companies of J. Brockhouse & Co., Ltd., with notes on the products or activities of each. To facilitate reference, there is also an alphabetical list of products.

LONDEX, LTD., Anerley Works, 207 Anerley Road, London, S.E.20.—Illustrated brochure 119/F giving particulars of the range of pressure and vacuum switches made by the company in self- and hand-resetting types for use with compressed air, hydraulic, and vacuum systems. The range includes units for operation by pressures from $\frac{1}{2}$ in. w.g. up to 5,000 lb. per sq. in. and by degrees of vacuum from 2 to 30 in. mercury gauge, also switches of flame-proof and weather-proof designs. A switch can be supplied that operates when a pre-set difference between two applied pressures is reached, and there is also a unit which is actuated by either an increase or a decrease in line pressure.

News of the Industry

Huddersfield

TAYLOR & JONES, LTD., Honley, are experiencing a steady home demand for reamers of various types, and the call from export markets is maintained at a good level. In the latter connection, we may note recent orders from Canada, South Africa, India, Belgium, Holland, Switzerland, Spain, Austria, Finland, Iceland and Mexico. A substantial order for expanding hand reamers fitted with carbon-steel blades was recently received from Argentina. For expanding hand reamers and reamers with fixed pilots there is an increasing request. These tools can be supplied with patented helical blades of high-speed steel, also with straight blades. Machine and shell reamers, of the expanding type, and solid hand and machine reamers, are other active lines. Valve reseating cutters are also produced at these works.

J. GOULDER & SONS, LTD., Kirkheaton, are busy with the production of jigs, fixtures, moulds, and tooling equipment, as well as a variety of components for the builders of gas turbine and piston-type aero engines, airframes, and helicopters. Transfer-line work fixtures have recently been supplied to the motor-car industry. In the works our attention was drawn to a No. 4 rolling gear testing machine for gears up to 32-in. centres and 48 in. diameter, and to two horizontal-type machines for shaft gears. These machines are destined for a tractor works in Scotland and we hope to describe them in due course. We also noted a batch of No. 2 size machines in progress, and No. 1 size machines are on order for Canada, Italy and Japan. Recent additions to the plant include a Dean, Smith & Grace 17- by 48-in. centre lathe fitted with hydraulic copying equipment, a Lang lathe, of similar size, also arranged for hydraulic copying, a Ward No. 10 combination turret lathe with extended bed, and two Parkinson Adapta milling machines.

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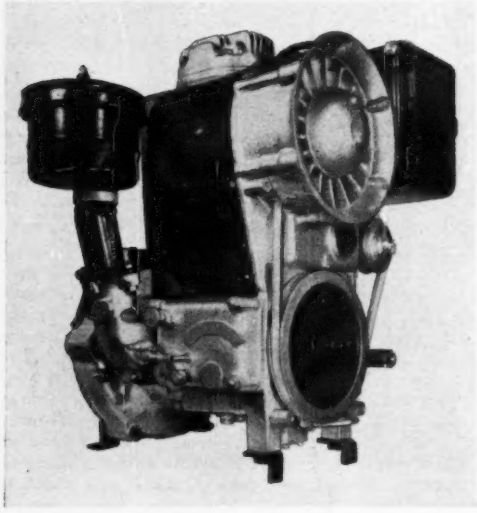
This air-cooled, single-cylinder 2-stroke diesel engine is now being produced, under licence from Germany, by Drayton Diesels, Ltd., West Drayton, Middlesex, for industrial, agricultural, and marine applications. It is available with ratings of 8 and 9 b.h.p. and weighs only 150 lb.



HUDDERSFIELD GAUGES, LTD., Waterloo, report a good home and export demand for their various types of precision instruments. Orders are in hand for vernier calipers ranging from 6 to 72 in. capacity, vernier height gauges, from 10 to 48 in., vernier depth gauges from 4 to 12 in., and gear tooth calipers for various pitches. Graduations on these instruments may be either English or Metric. Our attention was drawn to the firm's new height gauge, which is being made in capacities from 12 to 72 in. It has a stabilized beam, and a square thread screw whereby adjustments can be made from either the top or bottom. We hope to describe this gauge more fully at a later date. Keith combination slip gauge blocks, in 81- and 48-piece sets, also the smaller mechanics' and micrometer sets, are in regular demand. Other products include wire rope gauges, 5- and 10-in. sine bars, straight and circular graduated scales. In addition, repair work on vernier instruments, micrometers, and comparators is undertaken. A new folder has recently been issued describing the various gauges mentioned above.

RELIANCE GEAR CO., LTD., Union Street, are busy with the cutting of spur, bevel and worm gears, also the production of standard worm reduction units of 5- and 7½-in. centres, and gearboxes for actuating valves. Repetition machining and capstan lathe work, as well as general machining, are also undertaken on a substantial scale. The

latest addition to the plant is a Gleason 12-in. capacity bevel gear generating machine.

KELLAM & BROOKE, LTD., Queens Mill Road (head office—35 Hales Street, Coventry), report a steady demand on the services which they offer for the design and production of special-purpose machinery, machine tools, jigs and fixtures, torque loading equipment, and test rigs. A variety of general engineering work is also in hand.

BROOMFIELD ENGINEERING CO., LTD., Folly Hall, are experiencing a well-maintained demand for jigs, fixtures, tools and gauges of various types. The latter include tungsten-carbide and tool-steel plug gauges, ring and gap gauges, receiver and position gauges, and reference rings.

N. C. ASHTON, LTD., St. Andrew's Road, inform us that there is a steady demand for aluminium bronze alloys in ingot, billet and wrought forms. Three 48 in. diameter by 2 in. thick seam welding discs, forged from 1 per cent chrome-copper alloy, of 125 Brinell hardness, were recently supplied. There is also a well-maintained demand for Narite wear- and rust-resisting alloy for press tools and dies, and we may note export business with Sweden and Switzerland. This material which has a high compressive strength, requires no heat-treatment, has a hardness exceeding 375 Brinell, can be cast, and is reasonably machinable. The "soapy" surface takes a high degree of polish and becomes work-hardened in service, so that the production of deep-drawn pressings, also pressings in such materials as mild and stainless, and Nimonic alloys, is greatly facilitated. A revised brochure concerned with Narite has recently been issued. A ring rolling mill of the firm's own design has been installed for operations on non-ferrous rings.

EDWIN MILLS & SON, LTD., Aspley Works, are engaged in the production of a variety of hydraulic and electric presses for cloth finishing, waste paper baling, oil extraction and other purposes, for customers both at home and abroad. Hydraulic presses range up to 500 tons capacity, and are built in both vertical and horizontal types, while the smaller electric presses are built in sizes up to 18 tons.

HOPKINSONS, LTD., Britannia Works, are experiencing a brisk home and overseas demand for valves and boiler mountings of various types. These works were recently visited by members of the Canadian Trade Mission, and Canada is an important export market for the firm's products. A good volume of work is in hand for Central Electricity Authority power stations, including the new atomic plants. The new heavy machine and fitting shop has been completed and 36- and 60-in. bore Tansphere valves are in production for nuclear power station applications. Business in oil purifiers is maintained at a steady level.

The local gauge and tool manufacturers referred to in these notes will be displaying their products at the Gauge and Tool Exhibition to be held at Olympia, London, in May.

H. B.

Lecture on Spark Machining

A lecture on spark machining was given recently by Mr. E. A. Sweetman, chief electrical engineer, Electro-Mechanical Department, Wickman, Ltd., Coventry, as one of a series dealing with various engineering subjects, organized by the Borough Polytechnic, Borough Road, London.

The lecturer explained the principles of spark machining, and discussed the ways in which the process had facilitated the production of sample workpieces. He also drew attention to some applications of the process for performing certain metal cutting operations which would otherwise be considered impracticable. In this connection a 4¾-in. long block of Nimonic 90 was shown, in which holes of 0·035 and 0·075 in. diameter had been produced by a spark machining method which has been developed as a result of investigations recently undertaken by the lecturer's company. The set-up for performing this operation was described in MACHINERY, 91/867—11/10/57.

At the end of the lecture the new colour film entitled "The Wickman Erodomatic" was shown. In this film, the various features of the two Erodomatic machines at present available are explained in some detail, and reference is made to a lead-screw and nut attachment which can be provided to permit of cutting screw threads by spark machining. As already mentioned in MACHINERY, 91/1060—1/11/57, sequences covering the operations necessary for the production of dies for gas tap bodies and spoon handles are included.

A companion booklet, entitled "The Working of Metals by Spark Machining" has recently been made available. Extending to 30 pages, this booklet gives an explanation of the spark machining process, and includes useful information concerning surface finish, cutting rate, spark gap, and electrode material and length. Some examples of work that has been performed by spark machining, and views of Erodomatic machines installed in the works of various companies are shown in well reproduced illustrations. Both machines are described, also attachments that are available, for automatically stopping the working cycle, setting the electrode accurately vertical, and screw cutting.

Thomas Mercer Centenary

Thomas Mercer, Ltd., Eywood Road, St. Albans, celebrate their centenary this year. The company was established in 1858 for the manufacture of marine chronometers, and in this field a high degree of success has been achieved.

Design and manufacture of clocks followed, and they have been installed in many famous ships including the *Queen Mary* and the *Queen Elizabeth*. The experience gained from the production of chronometers also led to the development of instruments for a variety of purposes where accurate timekeeping is essential, including time switches for radio beacons, and clocks for the measurement of the tide and for surveying purposes.

In 1931, the first of a comprehensive range of dial measuring instruments was produced, and this side has grown rapidly in size and importance.

With the introduction of new materials and techniques and the demands of many industries for methods of fine and rapid measurement, Thomas Mercer (Air-gauges), Ltd., was formed in 1950, and the manufacture of air gauge units was begun. The Mercer air gauge system is now widely known and finds application in numerous branches of industry and in research.

Coming Events

INCORPORATED PLANT ENGINEERS. *Peterborough Branch.* January 7, at 7.30 p.m., at the White Lion Hotel, Church Street, Peterborough; paper on "Production and Maintenance in an Automobile Factory," by K. B. O'Kell. *Dundee Branch.* January 13, at 7.30 p.m., at Mathers Hotel, Dundee; paper on "Planned Maintenance," by A. J. MacIntyre.

INSTITUTION OF ENGINEERING INSPECTION. *Coventry and District Branch.* January 7 at 7.30 p.m., at the Coventry Technical College, Coventry; paper on "Non-Destructive Testing as Applied to Aircraft Materials," by W. G. King. *Leeds Branch.* January 7, at 7.30 p.m., at the Leeds Church Institute, Albion Place, Leeds, 1; paper on "The Use of Hard Chrome Plating in Engineering," by C. Warrad.

INSTITUTION OF ENGINEERING DESIGNERS. January 13, at 7.15 p.m., at the Northern Architectural Association Hall, 6 Higham Place, Newcastle-upon-Tyne; paper on "Shielded Arc Welding," by W. A. Woolcott.

INSTITUTION OF PRODUCTION ENGINEERS. *Liverpool Section.* January 8, at 7.30 p.m., at the Exchange Hotel, Tithebarn Street, Liverpool; lecture on "Inspection as an Aid to Production," by W. Maiden.

INSTITUTION OF ELECTRICAL ENGINEERS. *Northern Ireland Centre.* January 13, at 7.30 p.m., at the Institution of Mechanical Engineers, Sir William Whitla Hall, Queen's University, Belfast; paper on "Engineering Education in the Soviet Union," by P. E. Sleight, M.Eng., and Prof. E. Giffen, D.Sc., D.Phil., E. R. Laithwaite, M.Sc., and L. S. Piggott, M.S.c. *South-West Scotland Sub-centre.* January 7, at 7 p.m., at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow, C.2; paper on "Brushless Variable-speed Induction Motors," by Prof. F. C. Williams,

THE COMBUSTION ENGINEERING ASSOCIATION. *Midland Region.* January 13, at the Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham. 11 a.m.—paper on "Atomic Energy," by W. R. Wootton. 2.30 p.m.—film on "Combustion," by International Combustion, Ltd.

Industrial Notes

CHARLES HIRST (TOOLMAKERS), LTD., The address of this company is now Shentonfield Road, Sharston Industrial Area, Manchester, 22.

STANLEY WORKS (G.B.), LTD., Rutland Road, Sheffield 3, have extended their service department and have taken over complete responsibility for servicing Stanley electric tools made in the United States.

ENGINEERING AND ALLIED EMPLOYERS' WEST OF ENGLAND ASSOCIATION.—The address of the Department of Work Study and Staff Training is now Engineers' House, The Promenade, Clifton Down, Bristol 8. In addition, the offices of the Association formerly at Queen Square have been moved to Engineers' House.

THE 13TH ANNUAL INSTRUMENT AUTOMATION CONFERENCE AND EXHIBIT, sponsored by the Instrument Society of America, will be held in Philadelphia, Penn., U.S.A., from September 15 to 19. It will be international in scope, and particulars may be obtained from Mr. Fred. J. Tabery, 3443 So. Hill Street, Los Angles 7, Calif., U.S.A.

E.M.I. NUMERICAL CONTROL ON A VERTICAL MILLING MACHINE.—Under the above heading reference was made in MACHINERY, 91/1347—6/12/57, to a specially modified C.V.A.-Kearney & Trecker 2CES machine. We are asked to point out that E. H. Jones (Machine Tools), Ltd., Garantools House, Portland Road, Hove 3, Sussex, are sole distributors for C.V.A.-Kearney & Trecker products and that all enquiries should be addressed to them.

MOBIL OIL CO., LTD., Caxton House, Westminster, London, S.W.1. An industrial technical bulletin issued by the company is concerned with fire-resistant, water-base hydraulic fluids, and includes valuable practical information. Sections are devoted to the conditions which demand the use of a fire-resistant fluid; Mobil Nyvac No. 20 and 30; introduction and maintenance of these fluids; and control of fluid during use.

WORK STUDY CONFERENCE.—The British Institute of Management, Management House, 80 Fetter Lane, London, E.C.4, in association with seven other organizations, have organized a conference on work study which will be held at Caxton Hall, London, on February 6. Executives engaged in all types of management will discuss up-to-date developments in this field. Copies of the programme and full particulars can be obtained from the above address.

THE MORGAN CRUCIBLE CO., LTD., Battersea, London, S.W.11, have secured the rights to manufacture brush holders to British Patent 674,796. This patent, owned by

Signor Ing. G, Giambonini, Bellinzona, Switzerland, covers a new type of brush holder pressure finger, particularly intended for use with split brushes, and the associated brush holder. The arrangement is applicable principally to traction motors, but can also be employed on any type of machine where maximum brush stability is required.

NEW 10½-IN. DOUBLE DUO BAR ROLLING MILL.—On December 20, the Lord Mayor of Sheffield, Alderman A. Ballard, C.B.E., started up a new 10½-in. double duo rolling mill, which has recently been installed at the Attercliffe works of Sanderson Brothers and Newbould, Ltd., Sheffield, for rolling of high-speed, tool, and alloy steel bars from ⅜ to 1¾ in. diameter, with a maximum length of 60 ft. We hope to publish more details of the installation in an early issue.

MARCONI INSTRUMENTS, LTD., St. Albans, have formed a new engineering group. The main duties of this section will be as follows: general research investigations; research in connection with nucleonics; technical liaison with other research organizations; and the applications of semiconductors to the company's products. Mr. G. M. Ettinger, M.Sc., who has been appointed engineer-in-charge of this new group, previously held a senior post at the Whetstone Laboratories of the English Electric Co., Ltd., and has had considerable experience in connection with transistors and magnetic amplifiers.

THE 1958 NUCLEAR CONGRESS will be held at the International Amphitheatre, Chicago, Ill., from March 17 to 21. There will also be an atomic exposition, a "hot" laboratories and equipment conference, an atomic energy management conference, and an American power conference. More than 30 organizations are sponsoring these events. The Engineers Joint Council is the co-ordinating agency and the American Institute of Chemical Engineers will be responsible for the management. Full particulars may be obtained from Mr. Joel Henry, American Institute of Chemical Engineers, 25 West 45th Street, New York 38, N.Y., U.S.A.

UNION CARBIDE, LTD., 103 Mount Street, London, W.1, have added a 98 per cent vanadium oxide to their range of alloys and metals. This product should be of particular interest to ferro alloy producers and makers of ferrous and non-ferrous alloys. Reduction of alkali oxide content to not more than 2 per cent is of importance for furnace operations because of the appreciable reduction of fume hazards. The new oxide also has the advantages of reduced sulphur, silica, and other contaminants, so that the production of high-quality vanadium steels will be facilitated. It can be supplied in either a dense fused form suitable for direct addition to an alloying furnace, or in granular form.

Correction

In the advertisement for A. A. Jones & Shipman, Ltd., which appears on page 86 of this issue of MACHINERY, the accuracy of table reversal for the Model 1300 10- by 27-in. precision grinding machine, there illustrated, is given incorrectly. It should read "within ± 0·0005 in.".

Accuracy of Large Aircraft Parts

(Continued from page 3)

dimensions by etching all surfaces, or selected areas only. In particular, the process should prove of value in reducing the extent of warping, and enabling very thin webs to be obtained. Chemical milling is not confined to light alloys, and its importance is likely to increase as other materials are more widely adopted for aircraft construction. Good results have been obtained with stainless steels, and it is reported that the process also shows promise for certain alloy steels of non-stainless types. In addition, titanium alloys can be successfully processed provided that the initial hydrogen content is sufficiently low.

The problems of rigid volume control to secure minimum weight will no doubt be successfully solved, but in view of the rapid advances in aircraft and missile design, intensive research will be necessary in connection with both orthodox machining and other production processes if construction is not to be unduly delayed. Such research is inevitably costly, but in this respect an industrial nation, such as ours, can no longer afford to economize.

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3/1/58

Personal

MR. JOSEPH R. GREENWOOD, JUNR., has recently been elected a director of Craven Brothers (Manchester), Ltd., Vauxhall Works, Reddish, Stockport.

MR. W. T. VIZER-HARMER, hitherto director and commercial manager of Steel, Peech and Tozer (branch of the United Steel Companies, Ltd.), has been appointed commercial director of the branch. He has been succeeded as commercial manager by MR. J. MACKENZIE-MAIR, who will be responsible for all commercial and sales matters.

MR. W. J. MORGAN. We are pleased to report that Mr. W. J. Morgan, M.B.E., General Manager of the Machine Tool Trades Association, is now better and is out of hospital. He is at present recuperating at Hove and we wish him a speedy and complete recovery.

AIR VICE-MARSHAL G. M. C. SPENCER, C.B., C.B.E., has joined the technical liaison staff of William Jessop & Sons, Ltd., Brightside Works, Sheffield. He will be particularly concerned with titanium and the vacuum melted steels produced by the company, and their uses in the aircraft and associated industries.

Machine Tool Share Market

Business in stock markets dwindled to very small proportions during the period under review, but despite the paucity of trading, a fairly steady tone was maintained.

There was a quiet demand for British Funds and similar gilt-edged stocks and fractional improvements were shown on balance.

Interest in the commercial and industrial sections remained moderate and selective, and quotations consequently moved within narrow limits. No definite tendency developed, and price changes were small and irregular.

Among machine-tool issues Armstrong Stevens advanced 3d. to 17s.; Birmingham Small Arms, 6d. to 27s.; Churchill Machine Tool, 1½d. to 17s. 7½d.; and John Shaw & Sons (Wolverhampton), 1½d. to 11s. 10½d. On the other hand, British Oxygen lost 1s. 3d. at 32s. 6d.; Alfred Herbert, 2s. 6d. at 57s. 6d.; Kitchen & Wade, 6d. at 11s.; Modern Engineering, 9d. at 11s.; F. Pratt, 7½d. at 20s.; and Wadkin, Ltd., 1s. at 20s. 3d.

ABWOOD MACHINE TOOLS, LTD.—Interim dividend 5 per cent (same).

COMPANY		Denom.	Middle Price
Abwood Machine Tools, Ltd.	Ord.	1/-	1/-
Armstrong, Stevens & Son, Ltd.	Ord.	5/-	17/-
Allen (Edgar) & Co., Ltd.	Ord.	£1	30/-
" " "	5% Prf.	£1	15/-*
Arnott & Harrison, Ltd.	Ord.	4/-	14/-
Asquith Machine Tool Corp., Ltd.	Ord.	5/-	18 9
" " "	6% Cum. Prf.	£1	17 9
Birmingham Small Arms Co., Ltd.	Ord.	£1	27/-
" " "	5% Cum. "A" Prf.	£1	15/6
" " "	6% Cum. "B" Prf.	£1	17/6
" " "	4% 1st Mort. Deb.	Stk.	84½
British Oxygen Co., Ltd.	Ord.	£1	32 6
" " "	6½% Cum. Prf.	£1	20/6
Brooke Tool Manufacturing Co., Ltd.	Ord.	5/-	5/6
Broom & Wade, Ltd.	Ord.	5/-	10/-
" " "	6% Cum. Prf.	£1	16 10½
Brown (David) Corporation, Ltd.	5½% Cum. Prf.	£1	12/6
Buck & Hickman, Ltd.	6% Cum. Prf.	£1	18/9xd
Butler Machine Tool Co., Ltd.	Ord.	5/-	10/-
" " "	5% Cum. Prf.	£1	15/9
C.V.A. Jigs, Moulds & Tools, Ltd.	5½% Red. Cum. Prf.	£1	13/9xd
Churchill (Charles) & Co., Ltd.	Ord.	2/-	4 7½
" " "	6% Cum. Prf.	£1	26/3†
Churchill Machine Tool Co., Ltd.	Ord.	5/-	17 7½
" " "	6% Cum. Prf.	£1	18/9
Clarkson (Engrs.) Ltd.	Ord.	5/-	10/6
Cohen (George), Son & Co., Ltd.	Ord.	5/-	10 6
" " "	4½% Cum. Prf.	£1	14/3
Coventry Gauge & Tool Co., Ltd.	Ord.	10/-	16/-
" " "	5% Cum. Red. Prf.	£1	17/6
Coventry Machine Tool Works, Ltd.	Ord.	4/-	8/3
Craven Bros. (Manchester), Ltd.	Ord.	5/-	6/10½
Elliott (B.) & Co., Ltd.	Ord.	1/-	3/-
" "	4½% Red. Cum. Prf.	£1	13/9xd
Expert Tool & Case Hardening Co., Ltd.	Ord.	2/-	1/9
Firth Brown Tools, Ltd.	4% Cum. Prf.	£1	12/-
Greenwood & Batley, Ltd.	Ord.	£1	46/10½
Harper (John) & Co., Ltd.	Ord.	5/-	14/6
" "	4½% Red. Cum. Prf.	£1	12/9
Herbert (Alfred), Ltd.	Ord.	£1	57 6
Holroyd (John) & Co., Ltd.	"A" Ord.	5/-	11/3
" " "	"B" Ord.	5/-	10/3
Jones (A. A.) & Shipman, Ltd.	Ord.	5/-	23/9
" " "	7% Cum. Prf.	5/-	5/-xd
Kayser, Ellison & Co., Ltd.	Ord.	£1	55 6
" " "	6% Cum. Prf.	£1	18/3xd
Kendall & Gent, Ltd.	Ord.	5/-	8/-
Kerry's (Gt. Britain) Ltd.	Ord.	5/-	6/-
Kitchen & Wade, Ltd.	Ord.	4/-	11/-
Martin Bros. (Machinery), Ltd.	Ord.	2/-	2/4½
Massey, B. & S., Ltd.	Ord.	5/-	7/9
Modern Engineering Machine Tools, Ltd.	Ord.	5/-	11/-
Newall Engineering Co., Ltd.	Ord.	2/-	5/-
Newman Industries, Ltd.	Ord.	2/-	2/9
" " "	6% Prf. Ord.	5/-	5/6
Noble & Lund, Ltd.	Ord.	2/-	4/9
Osborn (Samuel) & Co., Ltd.	Ord.	10/-	75/-
" " "	5½% Cum. Prf	£1	24/6
Pratt (F.) & Co., Ltd.	Ord.	5/-	20/-
Scottish Machine Tool Corporation, Ltd.	Ord.	4/-	4/9
Shardlow (Ambrose) & Co., Ltd.	Ord.	£1	35/-xd
Shaw (John) & Sons, Wolverhampton, Ltd	Ord.	5/-	11/10½
Sheffield Twist Drill & Steel Co., Ltd.	Ord.	4/-	33/9
" " "	5% Cum. Prf.	£1	15/-xd
Stedall & Co., Ltd.	Ord.	5/-	5/3
Tap & Die Corporation, Ltd.	Ord.	5/-	8/-
" " "	4½% Deb. 1961-1977	Stk.	91
Wadkin, Ltd.	Ord.	10/-	20/3
Ward (Thos. W.), Ltd.	Ord.	£1	70 7½
" "	5% Cum. 1st Prf.	£1	15/-xd
" "	5% Cum. 2nd Prf.	£1	23/9xd
Willson Lathes, Ltd.	Ord.	1/-	2/4½

The Middle Prices given in the list are in several cases nominal prices only and not actual dealing prices. Every effort is made to ensure accuracy, but no liability can be accepted for any error. * Sheffield price. † Birmingham price.